NORMAL ANATOMY

OF THE

LIVER.

BY

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NORMAL ANATOMY OF THE LIVER.

LIVER, Normal Anatomy.—Syn. Gr. ηπαρ; Lat. *jecur, hepar;* Fran. *foie;* Germ. *Leber;* Ital. *fegato.* The liver is a conglomerate gland of large size, appended to the alimentary canal, and performing the double office of separating certain impurities from the venous blood of the chylopoietic viscera, previously to its return into the general circulation, and of secreting a fluid necessary to digestion—the bile.

It is *situated* in the abdomen, in the right hypochondriac region, and extends across the epigastrium into the left hypochondriac region. Superiorly it ascends to a level with the sixth or seventh rib, diminishing the cavity of the chest on the right side, and inferiorly it approaches by its anterior border, the lower margin of the thorax.

The general *form* of the liver is flattened, being broad and thick towards the right extremity, and narrow and thin towards the left. Glisson compared its shape to the segment o, an ovoid cut obliquely in the direction of its length, and Dr. Alexander Monro to the hoof of an ox rounded superiorly. Its superior surface is convex; the inferior irregularly concave; the posterior border is thick and rounded, and the anterior thin and sharp.

Its *position* in the abdomen is oblique, the convex surface, in the erect posture of the body, being directed upwards and forwards, and the concave downwards and backwards. The broad border is posterior and superior, and the thin margin anterior and inferior. If the trunk be inclined forwards the free edge of the liver may be felt, extending below the margin of the thorax.

It is in *relation* by its *convex surface,* superiorly with the diaphragm, which separates it from the under surface of the right lung and from the heart; anteriorly with the diaphragm and transversalis muscle, and with the sheath of the rectus and linea alba at the epigastrium; and on the right side with the diaphragm and transversalis muscle, which are interposed between it and the seven or eight lower ribs. Its *inferior* or *concave surface* is in relation with the anterior aspect of the stomach, the ascending portion of the duodenum, the transverse colon, the right supra-renal capsule, and the right kidney, and sometimes by its left extremity with the upper end of the spleen. The *posterior border* rests against the diaphragm, which intervenes between it and the vertebral column, and is in contact with the inferior vena cava, œsophagus, and right pneumogastric nerve. The *anterior border* is free and in relation with the transversalis muscle, which separates it from the cartilagés of the lower ribs, with the round ligament at the notch, and with the sheath of the rectus and linea alba at the epigastrium.

The liver is *retained in its place* by duplicatures of peritoneum which pass between its convex surface and posterior border and the diaphragm, and by a fibrous cord which crosses from the linea alba to the inferior vena cava. These are the *ligaments* of the liver; they are five in number, the broad, the two lateral, the coronary, and the round ligament.

Fig. 32.

The upper or convex surface of the liver.

No 1, the right lobe; 2, the left lobe; 3, a part of the lobus Spigelii seen projecting beyond its posterior border; 4, 4, the anterior or narrow border; 5, the notch in the anterior border that gives passage to the round ligament 12; 6, 6, the posterior or rounded bord r; 7, the broad ligament; 8, the left lateral ligament; 9, the right lateral ligament; 10, the point of separation of the layers of the right lateral ligament to inclose the oval space, 11, 11; 12, the round ligament; 13, the fundus of the gall-bladder projecting beyond the anterior margin of the liver. The notch upon the anterior margin corresponding with the gall-bladder is also seen; 14, the inferior vena cava emerging from the liver in the centre of the oval space of the coronary ligament. The small vessels seen ramifying upon the surface of the organ are superficial lymphatics.

The *broad ligament,* (*fig.* 32, 7) (falciform, longitudinal, l. latum, l. suspensorium hepatis) is an antero-posterior duplicature of ritoneum which exte nds from the notch on the anterior margin of the liver to the superior part of its posterior border. It is broad in front where it incloses the round ligament, and becomes narrow as it passes backwards; hence its synonym, *falciform.* It serves to connect the convex surface of the liver with the linea alba and diaphragm.

The *lateral ligaments* (*fig.* 32, 8, 9)

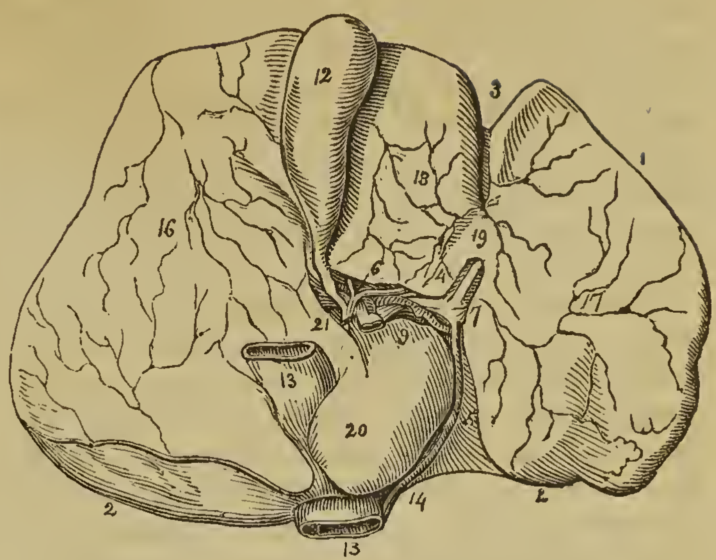
(triangular) are two triangular folds of peritoneum which commence at each extremity of the posterior border of the liver and converge towards the termination of the broad ligament. They are broad near the extremities of the organ, and permit of a certain degree of motion in the right and left lobes, but become narrow as they approach the middle line. The two layers which compose the right lateral ligament separate as they pass inwards, and partly inclose an oval space (11, 11) of variable size, which is uncovered by peritoneum and in close contact with the diaphragm; the remainder of the space is bounded by the division of the layers of the broad and left lateral ligaments. The peritoneum surrounding this space, with the contained cellular tissue, which is large in quantity and connects the posterior border of the liver firmly with the right leaflet of the central tendon of the diaphragm, constitutes the *coronary ligament*. The inferior vena cava (14) emerges from the liver at about the middle of this space previously to its passage through the quadrilateral opening in the tendon of the diaphragm. The left lateral ligament, near to its extremity, advances a little upon the upper surface of the left lobe.

The *round ligament*, (*fig.* 33, 12) (ligamentum teres, umbilicale) is a rounded fibrous cord resulting from the obliteration of the umbilical vein of the fœtus. It is contained in the anterior margin of the broad ligament, and may be traced forwards along the linea alba to the umbilicus, and backwards through the notch in the anterior border of the liver and along the longitudinal fissure to the posterior border, where it is connected with the coats of the inferior vena cava.

Turning to the under surface of the liver we have to examine certain *fissures* which divide this aspect of the organ into lobes; the fissures are five in number; the longitudinal, the fissure for the ductus venosus, the transverse, the fissure for the gall-bladder, and the fissure for the vena cava.

The *longitudinal fissure*, (*fig.* 33, 4, 4) (sulcus longitudinalis, umbilicalis, horizontalis) extends, as it name implies, longitudinally across the concave surface of the liver from the notch on the free margin of the organ to its posterior border. At about two-thirds from the anterior border it is met by a short fissure, the transverse, which joins it at right angles. The longitudinal fissure up to this point is deep and is generally covered in by an arch of variable breadth (*pons hepatis*, *fig.* 33, 19) which connects the adjoining sides of the right and left lobes; beyond this point it is shallow and takes the name of *fissure for the ductus venosus* (5) from containing the fibrous cord into which the ductus venosus is converted after the cessation of fœtal circulation. The longitudinal fissure marks the division of the liver upon its under surface into a right and left lobe, and contains the fibrous cord of the round ligament, which is the degenerated umbilical vein of the fœtus. Opposite the extremity of the transverse fissure the fibrous cord is often partially dilated and communi-

Fig. 33.



The under or concave surface of the liver.

Nos. 1, 1, the anterior border; 2, 2, the posterior border; 3, the notch upon the anterior border; 4, 4, the longitudinal fissure containing the fibrous cord of the round ligament; 5, the fissure for the ductus venosus; 6, the transverse fissure; 7, the point of union of the three fissures, the longitudinal, the transverse, and that for the ductus venosus; 9, the portal vein in the transverse fissure, the hepatic artery, and the trunk of the ductus communis choledochus; 11, the cystic duct; 12, the gall-bladder; 13, 13, the inferior vena cava passing through its fissure; 14, the cord of the ductus venosus, joining the inferior cava as that vessel emerges from the substance of the liver; 15, part of the oval space on the posterior border of the liver; 16, the right lobe; 17, the left lobe; 18, the lobulus quadratus; 19, the pons hepatis; 20, the lobus Spigelii; 21, the lobus caudatus.

cates with the portal vein. This is an indication of the natural inosculation subsisting between these two vessels during intra-uterine existence.

The *transverse fissure* (*fig.* 33, 6) (sulcus transversus, sulcus venæ portæ) is short and deep and about two inches in length; it commences near the middle of the under surface of the right lobe and passes transversely inwards to join the longitudinal fissure. It is the hilus of admission to the vessels of the liver, and gives passage to the hepatic artery, portal vein, and hepatic ducts, as well as to the lymphatics and nerves. The transverse fissure is bounded before and behind by the elevated borders of the lobus quadratus and lobus Spigelii. These lobes were named by the older anatomists the portal eminences, and were considered as the pillars which flanked the entrance to this great portal of the liver.

The *fissure* or rather the *fossa for the gall-bladder* is the shallow angular depression which lodges the biliary sac. It is broad in front and generally marked by a notch upon the anterior border of the liver, and narrows as it passes backwards. It is situated in the right lobe and runs parallel with the longitudinal fissure, while posteriorly it opens into the commencement of the transverse fissure.

The *fissure for the vena cava* (*fig.* 33) is situated in the same longitudinal line with the preceding, but upon the posterior border of the liver. It commences at the under surface of the organ and terminates upon the upper part of the posterior border at about the middle

of the oval space inclosed by the coronary ligament. This fissure is always very deep and surrounds the vena cava for two-thirds or three-fourths of its cylinder. Sometimes it is converted into a canal by a thin layer which is stretched across it from the lobus Spigelii to the contiguous border of the right lobe. The hepatic veins pour their blood into this portion of the vena cava.

These five fissures taken collectively, namely, the longitudinal fissure and fissure for the ductus venosus on the left, the fissures for the gall-bladder and vena cava on the right, with the transverse fissure passing between them, are represented by Meckel as resembling the letter H, whereof the transverse bar is placed nearer to the posterior than to the anterior extremity. Viewing them in this way the two anterior branches are, the longitudinal fissure on the left and the fossa for the gall-bladder on the right; and the two posterior are, the fissure for the ductus venosus on the left, and the fissure for the vena cava on the right.

The existence of these five fissures upon the under surface of the liver causes its division into as many portions, which are named lobes, viz. the right, the left, the lobus quadratus, the lobus Spigelii, and the lobus caudatus.

The *right lobe*, (*fig.* 32, 1, *fig.* 33, 16,) (lobus major) is the largest division of the liver, and forms the whole of the bulky right extremity of the organ. It is convex upon its upper surface and irregularly concave below; at its right extremity and behind it is thick and rounded, and thin and sharp in front. It is separated from the left lobe on its convex surface by the broad ligament; beneath by the longitudinal fissure and fissure for the ductus venosus, and in front by the notch on the free margin of the liver. The transverse fissure and the fissures for the vena cava and gall-bladder are situated on the under surface of this lobe and serve to limit the boundaries of the three minor lobes; the lobus quadratus, Spigelii, and caudatus. Upon this surface it is marked by three depressions, one in front, of large size, for the right extremity of the transverse colon, and two behind, one for the right supra-renal capsule and another for the right kidney.

The *left lobe* (*fig.* 32, 2, *fig.* 33, 17,) (lobus minor) is four or six times smaller than the right; flattened in form, and thinned towards its circumference into a sharp margin. It is divided from the right lobe by the broad ligament above, by the notch in the anterior margin of the liver in front, and by the longitudinal fissure and fissure for the ductus venosus below. Superiorly it is convex and in relation with the diaphragm, to which it is connected by the left lateral ligament, and inferiorly it is concave, and presents a broad and shallow depression which rests upon the anterior surface of the stomach. By its extremity it sometimes touches the spleen, and by its posterior border corresponds with the termination of the œsophagus and with the right pneumogastric nerve.

The *lobus quadratus* (*fig.* 33, 18,) (anterior portal eminence) is a quadrilateral and slightly elevated division situated upon the under surface of the right lobe near to the middle line of the liver. It is bounded anteriorly by the free margin of the organ, posteriorly by the transverse fissure, to the left by the longitudinal fissure, and on the right by the fossa for the gall-bladder.

The *lobus Spigelii* (*fig.* 33, 20,) (posterior portal eminence) is a prominent conical lobe, smaller than the preceding, and situated near the posterior border of the liver, behind the two layers of the lesser omentum. Its base is triangular, and bounded in front by the transverse fissure; on the left side by the fissure for the ductus venosus, and on the right by the fissure for the vena cava and lobus caudatus, which last connects it with the under surface of the right lobe. By its anterior border it is in relation with the portal vein, by its left border with the fibrous cord of the ductus venosus, and by the right with the vena cava. Its posterior extremity is received into the angle of communication between the fibrous cord of the ductus venosus and the vena cava.

The *lobus caudatus* (*fig.* 33, 21,) is a tail-like appendage to the lobus Spigelii. It is extremely diversified in form, being sometimes well developed and a distinct lobe; at other times a mere vestige recognisible only to the eye of the experienced anatomist. Sometimes it is a slight ridge, merging into the surface of the liver on either side, and at other times is marked by a fissure on one side or even on both. Ordinarily it is an angular projection two or three inches in length, commencing by a narrow isthmus from the lobus Spigelii, passing obliquely outwards and forwards by the side of the gall-bladder, and subsiding at its extremity into the surface of the right lobe. The depression on the under surface of the right lobe, in front of this process, is for the reception of the curve of the ascending colon, and the posterior depressions for the right supra-renal capsule and right kidney.

The *coverings* of the liver are twofold, a serous investment, which is obtained from the peritoneum, and a proper fibrous capsule derived from the capsule of Glisson. The *peritoneum* encloses the whole of the liver with the exception of that part of the posterior border which constitutes the oval space (*fig.* 32, 11, *fig.* 33, 15,) and is surrounded by the coronary ligament, of the fossa for the gall-bladder, the fissure for the vena cava, and the transverse fissure. The *proper capsule* is most apparent upon those parts of the organ which are left uncovered by the peritoneum, particularly on the oval space upon its posterior border.

The *color* of the liver varies considerably, both with the period of life and with the greater or smaller proportion of blood or bile contained within its vessels. Thus in infancy it presents a light red colour, which deepens into a reddish brown in the adult, and increases in depth of shade with the age of the subject. If the individual have died from hæmorrhage, the liver appears bleached and presents a yellowish grey tint; if from general congestion,

it may assume a chocolate or purplish brown or a slate colour, and if from obstruction to the bile-ducts, a variable shade of yellow. Its *texture* is firm and dense, but extremely fragile, the fracture presenting a granular appearance.

The *dimensions* of the liver are very considerable, as may be inferred by recollecting that this is the largest organ in the body. Through the longest diameter from the extremity of the right to the edge of the left lobe, it measures about twelve inches; from before backwards, through the transverse diameter of the right lobe, about seven inches, and through the thickest part of the right lobe, in a vertical direction, about four inches. These measurements, however, can only be received as an approximation to the average, for the size of the organ varies in different individuals; thus it is larger in males than in females, and is more bulky in persons of sedentary habits than in those who are robust and active. Its *weight* is about five pounds; its relative weight to the entire body, as 1 to 36; and the *specific gravity* one half heavier than water.

Chemical analysis of the human liver has shewn that in 100 parts, there are, of

Water 61.79
Solid matters 38.21

Of 100 parts of the solid matters,

71.18 are soluble in water, hot or cold, or alcohol; and consist of, osmazome, stearine, elaine, resin, oleic and margaric acids, gelatine, and salivine.
28.72 are insoluble.
2.034 are salts; viz. chloruret, phosphate of potash, phosphate of lime, and oxide of iron.

Bullocks' liver, analysed by Braconnot, is, according to Berzelius, analogous to the preceding, the differences being dependent solely upon a difference of manipulation. 100 parts contain,

55.50 water.
44.50 solid matters, composed of,
Vessels and membranes ..18.94
Soluble matters 25.56

100 parts of the pulp of liver contained,

58.64 water.
20.19 dry albumen.
6.07 matter very soluble in water; slightly in alcohol; containing little nitrogen.
3.89 fat.
0.64 chloruret of potash.
0.47 phosphate of lime containing iron.
0.10 salt of potash combined with a combustible acid.

Varieties in the liver may be referred to one of two heads—varieties in form, and varieties in position.

Varieties in form occasionally occur, but they are more rare in the liver than in almost any other organ of the body. I have seen the left lobe so small as to appear but a mere appendage to the right, being connected to it only by a thin and narrow isthmus. Cruveilhier records an instance in which the left lobe was attached to the right merely by a vascular pedicle about half an inch in length; the extremity of the lobe being adherent to the upper part of the spleen. Deep and narrow grooves are occasionally seen upon the convex surface of the right lobe running in an antero-posterior direction; they correspond with projecting fasciculi of the diaphragm, and occur generally in women who have laced tightly. This surface is also marked frequently in females with deep channels, which are formed by the pressure of the ribs, and are also the result of tight lacing. The liver is sometimes constricted in the middle from this cause, and a dense fibrous band, produced by thickening of the fibrous capsule, extends around it like a belt. The lobes are occasionally divided by deep fissures into several additional lobes; the liver in this case presents a character which is normal amongst the lower animals. In a few instances the fossa for the gall-bladder has been found excavated so deeply as to render the fundus of the sac apparent through an opening on the upper surface of the liver, a peculiarity which is also normal amongst some of the lower tribes of animals.

Varieties of position are more frequent than those of diversity of form. During utero-gestation the liver is usually pressed considerably above its ordinary plane, so as to impede more or less the action of the diaphragm and produce embarrassed respiration. In an extremely fat subject I once saw the diaphragm raised by the liver to a level with the fourth intercostal space, measured near to the sternum. In its natural position the thin margin of the liver scarcely reaches the border of the thorax, but in women who have laced tightly during youth nothing is more common than to find this edge forced several inches below the base of the thorax, and altered in its form. In these cases the direction of the aspects of the organ are likewise changed; the convex surface looks directly forwards, instead of upwards and forwards, and lies in contact with the abdomina parietes. The concave surface is directed backwards in place of downwards and backwards, and the posterior border is forced upwards. In a sketch from the subject, now before me, the greater part of the convex surface of the organ is in contact with the abdominal parietes, and the free margin extends into the umbilical and lumbar regions. In another sketch, as a result of the enormous magnitude of the stomach from the same cause, the liver is raised almost perpendicularly, the extremity of the left lobe being in contact with the diaphragm, and the right lobe in the right iliac fossa. A part of the liver has been found in the sac* of inguinal and umbilical hernia. Various peculiar appearances are observed in the liver of the fœtus arising from arrest of development. Thus, for instance, the entire organ, or a part of it, may be situated in the chest, or from absence of development of the abdominal parietes the liver may form part of

* Gunzius de Herniis, in Portal's Anatomie Médicale.

an exabdominal tumour, and be uncovered excepting by the membranes of the ovum. But the most interesting and unexplained form of altered position is that in which the whole of the viscera of the body are transposed, and the liver becomes placed on the left instead of the right side. These cases are generally perfect, and the peculiarity does not seem to interfere with the life or functions of the subject. The liver presents its natural form and size, and with the simple exception of left for right, precisely the same relations. The aorta, of course, occupies the right side, and the venæ cavæ the left, while the stomach is transferred to the right. Sir Astley Cooper has preserved the viscera of an adult who was the subject of this transposition. And a few years since I had the opportunity of examining a similar case in the body of Smithers, a man who was executed for committing arson accompanied with loss of life in Oxford-street. The viscera of this man were perfectly healthy, the liver finely formed, and the general fabric robust.

The *gall-bladder (fig.* 33, 12,) (cystis fellea) is a membranous sac of a pyriform shape, situated in the shallow fossa upon the under surface of the right lobe, and lying parallel with the longitudinal fissure. For convenience of description it has been customary to divide it into a body, fundus, and neck (cervix), although no precise mark of division subsists between these parts. The *body* is the middle portion; the *fundus* the expanded extremity, which approaches the notch in the free border of the liver, and frequently extends beyond it; and the *neck* the narrow and tapering portion of the sac which enters the right extremity of the transverse fissure and forms the cystic duct.

The sac is in *relation* by its upper surface with the substance of the liver, and by the under part with the pylorus and ascending duodenum. The fundus corresponds with the right border of the rectus muscle, and may be felt in that situation when filled with gall-stones.

The *coats* of the gall-bladder are three:—1. an external or serous covering derived from the peritoneum, which covers all that portion of the sac which is not in contact with the substance of the liver. The gall-bladder is sometimes completely surrounded by the peritoneum, and hangs loosely connected with the liver by a duplicature of that membrane. 2. A fibrous layer* (nervous) composed of cellulo-fibrous tissue intermingled with tendinous fibres; and, 3. a mucous coat which lines the interior of the sac, and is continuous through the cystic and hepatic ducts with the mucous lining of the biliary structure of the liver, and through the ductus communis choledochus with the mucous membrane of the duodenum and alimentary canal. The internal surface of the mucous layer is raised into innumerable small ridges and folds (rugæ) by the ramifications of the cystic artery and its capillaries, which give to it a peculiarly reticulated appearance, and the interspaces of the rugæ are depressed into numerous small muciparous follicles. In the neck of the sac the mucous membrane is produced into from six to twelve small folds, forming a kind of spiral valve by means of which the bile is regulated in its descent into the duodenum, and assisted in its entrance into the gall-bladder. The existence of this peculiar valvular apparatus gives to the neck of the gall-bladder a sacculated appearance. The mucous membrane is but loosely connected with the fibrous coat, and the cystic artery with its branches ramify between them.

The excretory duct of the gall-bladder is the *cystic*, (*fig.* 33, 11); it is about an inch and a half in length, and in diameter about equal to the cylinder of a crow's quill. It is generally somewhat tortuous in its course, and appears sacculated from the continuation into it of the spiral valve. Upon entering the transverse fissure it unites with the excretory duct of the liver, the *hepatic duct*, and the junction of the two constitutes the ductus communis choledochus. The *ductus communis choledochus*, about three inches in length, descends through the right border of the lesser omentum, lying in front of the portal vein, and to the right of the hepatic artery, and opens into the duodenum by passing for some distance obliquely between its coats. It is united to the other vessels in its course by the cellular tissue of Glisson's capsule, and near to its termination is considerably constricted.

The excretory ducts of the liver and gall-bladder have three coats, an external or cellular coat, a middle or fibrous, and an internal mucous. A question exists among physiologists as to the probable muscularity of the middle coat in man; it is undoubtedly contractile, and in some few instances of obstruction has presented an appearance very closely resembling muscular fibres. Cruveilhier thinks the structure analogous to the dartos. In some animals, as in the horse and dog, this coat is clearly muscular.

Varieties in the gall-bladder.—The sac is sometimes enormously dilated without any apparent obstruction in its ducts. Occasionally in acephalous and anencephalous fœtuses it is altogether absent. In a preparation now before me of the liver of a fœtus at the full period, which lived for several hours after birth, and which presented, in anatomical structure, several peculiarities dependent upon arrest of development, the most careful dissection has failed to discover the slightest indication of gall-bladder. Among the lower mammalia, as in cats, a double or accessory gall-bladder is by no means uncommon. Kiernan has observed several instances of this variety. I myself have seen two, and have one at present before me. In the kinkaju an accessory gall-bladder is the normal character, and in the liver of a small animal preserved by Hunter in the Museum of the College of Surgeons, there are three gall-bladders.

Structure of the liver.—The liver is composed of lobules, of a connecting medium

* In the ox, according to Monro, this coat is distinctly muscular.

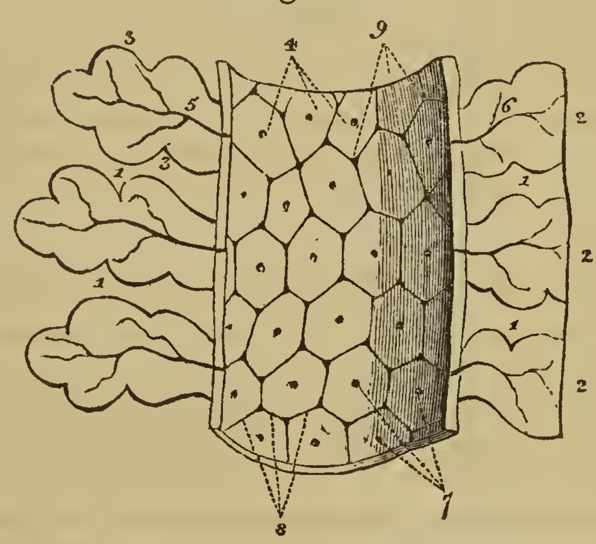
called Glisson's capsule, of the ramifications of the portal vein, hepatic duct, hepatic artery, hepatic veins, lymphatics and nerves. For an accurate knowledge of these different structures, anatomy is indebted to the labours of Mr. Kiernan, to whose paper on "The Anatomy and Physiology of the Liver," contained in the Philosophical Transactions for 1833, I shall have constant occasion to refer.

The small bodies (lobules, acini, corpuscula, glandular grains, granulations) of which the liver is composed were discovered by Wepfer in the liver of the pig, about two years previously to the appearance of Malpighi's celebrated work, "De Viscerum Structurâ Exercitatio Anatomica." Malpighi, unacquainted with Wepfer's discovery, examined and described these bodies, both in animals and in man, under the name of *lobules;* and the lobules he found to consist of smaller bodies, which he named *acini.* From some want of precision in Malpighi's descriptions, these two names have been confounded by the majority of succeeding anatomists; the term *lobules,* with its distinctive application, has been disregarded and forgotten, and the term *acini* has been applied to those minute bodies of which the liver appears to be formed when examined beneath the microscope with a moderate power, —the acini of Malpighi. So great, indeed, is the confusion of terms even in 1838, that we find a justly celebrated authority in minute anatomy, Müller, in speaking of Kiernan's discovery, using the following words. "He" (Kiernan) "describes the lobules of the liver (which by other anatomists are termed acini)," and further on he observes: "his description of their form is indeed similar to that which we have given above of the acini of the macerated liver of the polar bear." Now, setting aside the anachronism of discovery contained in the above quotation, which, as it appears to me, should have been; *our description of the acini of the polar bear is similar to his description of the form of the lobules,* inasmuch as Kiernan's discovery was published in 1833, and Müller's description of the macerated liver of the polar bear in 1835, I cannot but feel somewhat surprised in observing that Müller draws no line of distinction between the lobules and their supposed constituents the acini. Nay, that he would seem to imply that all anatomists were acquainted with the lobules, but that they assigned to them a different name. To prove that this is not the case, I quote a passage from his work upon the glands, published in 1830, in which he expresses himself unable to distinguish the elementary structure of the liver either in man or in numerous other mammalia, for he says, "In homine, ut in plurimis mammalibus, in hepatis superficie certa quædam particularum elementarium sive *acinorum* conformatio *conspici non potest.*" Now the question to be decided, is the meaning which he assigns in this quotation to the word *acinorum;* does he mean by that word the lobules or the acini of Malpighi? The solution is simple; we have it in his own words, and exhibited in a figure in which his peculiar views of the anatomy of the organ are clearly illustrated. In this figure, (*fig.* 217, page 485,) he says, "Observantur fines ductuum biliferorum elongati, seu cylindriformes acini, in figuris ramosis et foliatis variè dispositi." So that the acini of Müller in 1830 are the terminations of the biliferous ducts, corresponding therefore with the acini of Malpighi, and the lobular biliary plexus of Kiernan. In 1835, as instanced in the "macerated liver of the polar bear," the acini of Müller are the lobules of Malpighi and Kiernan.

Now seeing this indecision of opinion upon a subject of so great importance in relation to the proper understanding of the minute anatomy of the liver, I have deemed it my duty, in the service of anatomy, to place before my readers this cursory sketch of the history of the anatomy of the organ, and to establish the meaning of the terms I shall have occasion to use in describing its intimate structure. By the word *lobules* I shall mean, not the acini of anatomists, "which are anything or everything or nothing as the case may be," but the lobules of Malpighi and of Kiernan;—by the word *acini* I shall indicate the smaller bodies of which the lobules appear to be composed (acini of Malpighi and of all writers); but which have been shewn by Kiernan to be the meshes of a plexus of biliary ducts, the "lobular biliary plexus."

The *lobules* are small granular bodies of about the size of a millet-seed, of an irregular form, and presenting a number of rounded projecting processes upon their surface. When divided longitudinally (*fig.* 34) they have a foliated appearance, and transversely (*fig.* 35)

Fig. 34.

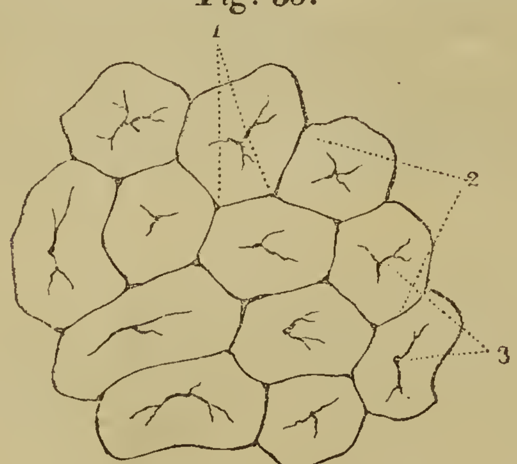


A longitudinal section of a sub-lobular vein.

Nos. 1, 1, longitudinal sections of lobules, presenting a foliated appearance. 2, 2, superficial lobules terminating by a flat extremity upon the surface of the liver; 3, 3, the capsular surface of a lobule; 4, the bases of the lobules seen through the coats of the vein and forming the canal in which the sub-lobular vein is contained; 5, the intra-lobular vein commencing by minute venules at a short distance from the capsular surface of the lobule; 6, the intra-lobular vein of a superficial lobule commencing directly from the surface; 7, the openings of the intra-lobular veins which issue from the centre of the base of each lobule; 8, the interlobular fissures seen through the coats of the sub-lobular vein; 9, interlobular spaces.

an irregularly pentagonal or hexagonal outline with sharp or rounded angles in proportion to the smaller or greater quantity of Glisson's capsule contained within the liver. Each lobule is divided upon its exterior into a base and a capsular surface. The *base* (*fig.* 34, 4) corresponds with one extremity of the lobule, is flattened and rests upon an hepatic vein, which is thence named *sub-lobular*. The *capsular surface* (*fig.* 34, 3, 3) includes the rest of the periphery of the lobule, and has received its designation from being inclosed in a cellular capsule derived from the capsule of Glisson. In the centre of each lobule is a small vein, the *intra-lobular* (*fig.* 34, 5, 6, *fig.* 35, 3) which is formed by the convergence of six or eight minute venules from the rounded processes situated upon the surface of the lobule. The intra-lobular vein thus constituted takes its course through the centre of the longitudinal axis of the lobule, pierces the middle of its base, and opens into the sub-lobular vein. The circumference of the lobule with the exception of its base, which is always closely attached to a sub-lobular vein, is connected by means of its cellular capsule with the capsular surfaces of surrounding lobules. The cellular interval between the lobules is the *interlobular fissure* (*fig.* 34, 8, *fig.* 35, 2), and the angular interstices formed by the apposition of several lobules are the *interlobular spaces* (*fig.* 34, 9, *fig.* 35, 1).

Fig. 35.



Angular lobules in a state of anæmia. From Kiernan's paper.

No. 1, interlobular spaces, containing the larger interlobular branches of the portal vein, hepatic artery and duct; 2, interlobular fissures; 3, intra-lobular veins formed by minute venules which converge towards the centre of the lobules.

The lobules present considerable variety of form dependent upon their situation and upon the manner in which they are examined. For instance, the section of a lobule divided transversely has an irregularly pentagonal or hexagonal figure, and longitudinally a foliated appearance. The lobules of the centre of the liver are angular and smaller than those of the surface, on account of the pressure to which, from their position, they are submitted by surrounding lobules. They are also more angular in some animals than in man. The surface of the liver of the cat, in which the portal vein is injected, has a beautiful reticulated appearance produced by angular meshes of an hexagonal figure; the hexagonal outline being formed by the interlobular fissures, reddened by the injection in the minute branches of the portal vein, and the included area by the lobule viewed upon its transverse diameter. In a section of the liver made from the free margin to the posterior border in the direction of the hepatic veins, the lobules are found to be larger than in a section made transversely to those vessels. The lobules of the exterior, particularly on the concave side and posterior border, are for the same reason larger from lying obliquely to the surface and corresponding in direction with the course of the sub-lobular veins. They are also more rounded from the absence of compression by surrounding lobules. But one appearance described by Kiernan is peculiarly characteristic of the lobules which form the surface of the liver, the *superficial lobules*. The word *surface* in this instance does not refer simply to the periphery of the organ, but also to the various canals channelled through its interior for the passage of the portal vein, hepatic ducts, and hepatic artery, and also for the main trunks of the hepatic vein, "all these canals being" as it were "tubular inflections inwards of the superficies of the liver." The superficial lobules (*fig.* 34, 2, *fig.* 35) are not terminated by a rounded extremity like those of the centre, but are flat and apparently incomplete, and as though cut across by a transverse incision. This peculiar form gives to the anatomist a natural surface which affords all the advantages for observation of a transverse section, and enables him to detect by external examination the relative condition of both the central portion and surface of the lobule. In these lobules also the intra-lobular hepatic vein, instead of being entirely concealed within the lobule, commences directly from the flat surface. A knowledge of this structure, says Kiernan, "enables us in injecting the hepatic veins to limit the injection to this system of vessels, which is effected by withdrawing the syringe when the injection appears in minute points upon the surface of the liver." Occasionally double lobules, or lobules having two intra-lobular veins, are seen upon the surface.

"Each lobule," according to Kiernan, "is composed of a plexus of biliary ducts, of a venous plexus formed by branches of the portal vein, of a branch (intra-lobular) of an hepatic vein, and of minute arteries; nerves and absorbents, it is to be presumed, also enter into their formation, but cannot be traced into them." "Examined with the microscope, a lobule is apparently composed of numerous minute bodies of a yellowish colour, and of various forms, connected with each other by vessels. These minute bodies are the acini of Malpighi." "If an uninjected lobule be examined and contrasted with an injected lobule, it will be found that the acini of Malpighi in the former are identical with the injected lobular plexus of the latter, and the bloodvessels in both will be easily distinguished from the ducts."

Glisson's capsule is the web of cellular tissue which envelopes the hepatic artery, portal vein, and ductus communis choledochus during their passage through the right border of the lesser

omentum, and which accompanies them along the portal canals and interlobular fissures to their ultimate distribution in the substance of the lobules. It forms for each of the lobules a distinct capsule which invests it on all sides with the exception of its base, and is then expanded over the whole of the exterior of the organ, constituting the *proper capsule* of the liver. Glisson's capsule serves to maintain the portal vein, hepatic artery, and hepatic ducts in connection with each other, and attaches them also to the surface of the portal canals; it connects the trunks of the hepatic veins to the surface of the canals in which they run; it supports the lobules and binds them together, and by its exterior expansion it invests and protects the entire organ. But Glisson's capsule, observes Kiernan, "is not mere cellular tissue; it is to the liver what the pia mater is to the brain; it is a cellulo-vascular membrane, in which the vessels divide and subdivide to an extreme degree of minuteness; which lines the portal canals, forming sheaths for the larger vessels contained in them, and a web in which the smaller vessels ramify; which enters the interlobular fissures, and with the vessels forms the capsules of the lobules, and which finally enters the lobules, and with the bloodvessels expands itself over the secreting biliary ducts. Hence arises a natural division of the capsule into three portions, a vaginal, an interlobular, and a lobular portion."

The *vaginal portion of the capsule* is loose and abundant; it occupies the portal canals and incloses the portal vein, hepatic duct, and hepatic artery. In the larger canals (*fig.* 36, 8,) it completely surrounds these vessels, but in the smaller ones (*fig.* 37,) is situated only on that side of the portal vein upon which the duct and artery are placed, the opposite side of the vein being in contact with the capsular surfaces of the lobules. It constitutes a medium for the ramification of the vaginal plexus formed by the vein, artery, and duct, previously to their entrance into the cellular interval of the interlobular fissures.

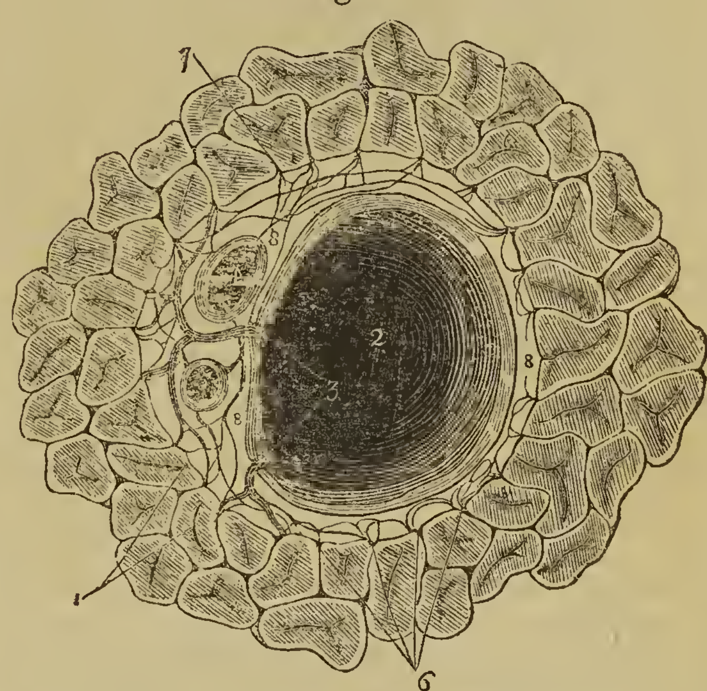
The *interlobular portion* forms the cellular capsule for each of the lobules and the bond of union between their contiguous surfaces. It supports the plexiform ramifications of the portal vein, hepatic artery, and duct, and is the medium of vascular communication between all the lobules of the liver.

The *lobular portion* forms sheaths for the minute vessels which enter the lobules, and a cellular parenchyma for the substance of those bodies.

The *portal vein* is formed by the union of the venous trunks which return the blood from the chylopoietic viscera, viz., the superior and inferior mesenteric, the splenic, and gastric veins. Commencing behind the pancreas where all these veins converge, the portal trunk ascends along the right border of the lesser omentum, lying behind the hepatic artery and ductus communis choledochus to the transverse fissure. At the transverse fissure it bifurcates into two trunks which enter the right and left lobes, and divide and subdivide as they take their course through the portal canals, until they are ultimately lost in the substance of the lobules. The branches of the portal vein are accompanied throughout their course by branches of the hepatic duct and hepatic artery, and they are inclosed and connected to the capsular surfaces of the lobules forming the portal canals, by Glisson's capsule. The branches of the portal vein are divisible into vaginal, interlobular, and lobular.

The *vaginal branches* (*fig* 36, 3, *fig.* 38, *f*) are the small veins which are given off by the portal trunks during their passage through the portal canals, and which are intended to convey

Fig. 36.



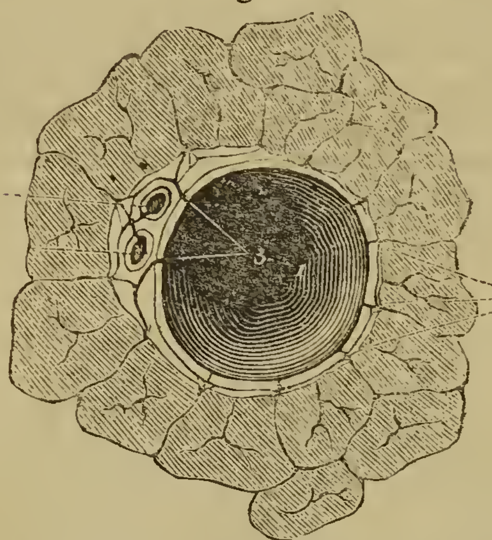
A transverse section of a large portal canal and its vessels. The lobules are in a state of general congestion, their central portions being more congested than their marginal portions. — From Kiernan's paper.

No. 1, Superficial lobules forming the parietes of the canal. In some the intra-lobular vein does not extend to the surface of the canal; this appearance depends upon the direction in which the incision is made. 2, The portal vein. 3, Vaginal branches arising from the vein and dividing into interlobular branches which enter the interlobular spaces. 4, Hepatic duct. It is seen to give off vaginal branches which divide into interlobular ducts, the latter enter the interlobular spaces. 5, The hepatic artery; it is seen giving off vaginal branches which divide into interlobular branches. and the latter enter the spaces with the branches of the portal vein and hepatic duct. 6, Three interlobular vessels, a duct, vein, and artery, entering each interlobular space. 7, A part of the vaginal plexus. 8, 8, Glisson's capsule, which completely surrounds the vessels.

their blood into the substance of the lobules. In the cellular sheath of Glisson's capsule which surrounds the portal vein, they inosculate freely with each other and form, together with the vaginal branches of the duct and artery, a vascular plexus, named from its situation the *vaginal plexus*. This vaginal plexus establishes a communication between the vaginal veins throughout the portal canals, and serves to equalise the supply of blood to the lobules. Opposite each interlobular space an interlobular vein is given off, which enters between the lobules and ramifies in the interlobular fissures. In the larger portal canals (*fig.* 36,) the vaginal plexus completely surrounds the portal vein, hepatic duct

and hepatic artery, and the interlobular spaces are supplied solely with branches which are derived from its ramifications. But in the smaller portal canals (*fig.* 37, *fig.* 38) the capsule of Glisson, upon which the plexus chiefly depends, is

Fig. 37.



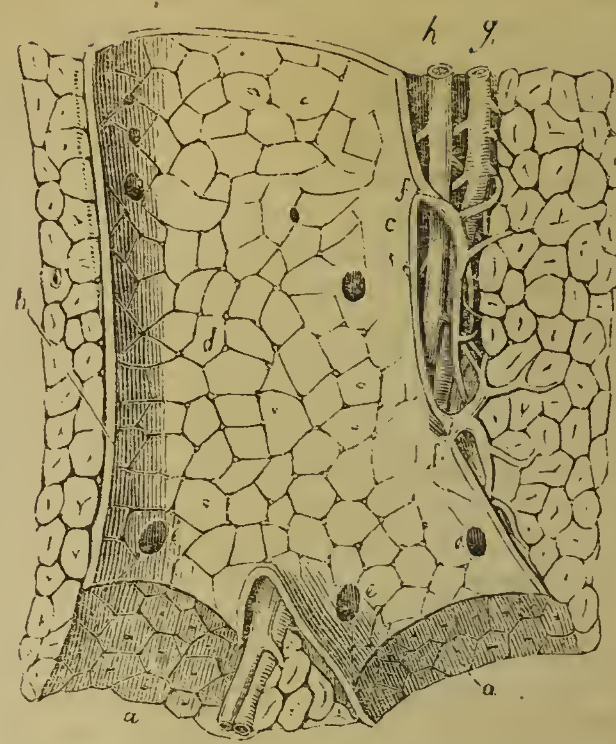
A transverse section of a small portal canal and its vessels. The lobules are in a state of general congestion. From Kiernan's paper.

No. 1, The portal vein; the greater part of its cylinder is in contact with the portal canal. 2, Interlobular branches of the vein entering directly the interlobular spaces, with branches of the artery and duct, without ramifying in the canal. 3, Two vaginal branches arising from the vein, and forming a vaginal plexus on that side of the vein, which is separated from the canal by Glisson's capsule. From the plexus the interlobular branches arise. 4, The hepatic duct giving off vaginal branches. 5, The artery giving off vaginal branches. Glisson's capsule is situated on one side only of the canal.

situated only upon that side of the vein, on which the duct and artery are placed, and the vaginal plexus consequently follows the same disposition. On the opposite side the portal vein being in contact with the lobules, gives off interlobular branches directly to the spaces. If the portal vein (*fig.* 38) be laid open in this situation, the form of the lobules bounded by the interlobular fissures will be distinctly apparent through its coats, and the openings of the interlobular veins will be found to correspond with the interlobular spaces.

The *interlobular veins* enter the intervals of the lobules through the interlobular spaces and divide into numerous minute branches, which ramify in the capsules of the lobules and then enter their substance. They cover with their ramifications the whole external surface of the lobules with the exception of their bases, and of those extremities of the superficial lobules which appear upon the surfaces of the liver. The interlobular veins communicate freely with each other and with the corresponding branches of adjoining lobules, and establish a general portal anastomosis of the freest kind throughout the entire liver. When the portal vein is well injected, these veins form a series of inosculations which surround all the lobules and give to the surface of the organ the appearance of a vascular network composed of irregularly pentagonal and hexagonal meshes. If the vein be only partially injected the interlobular vein in the interlobular space is alone filled, and the branches which it sends off into the neighbour-

Fig. 38.



Longitudinal section of a small portal vein and canal. The lobules are in a state of anæmia.—After Kiernan.

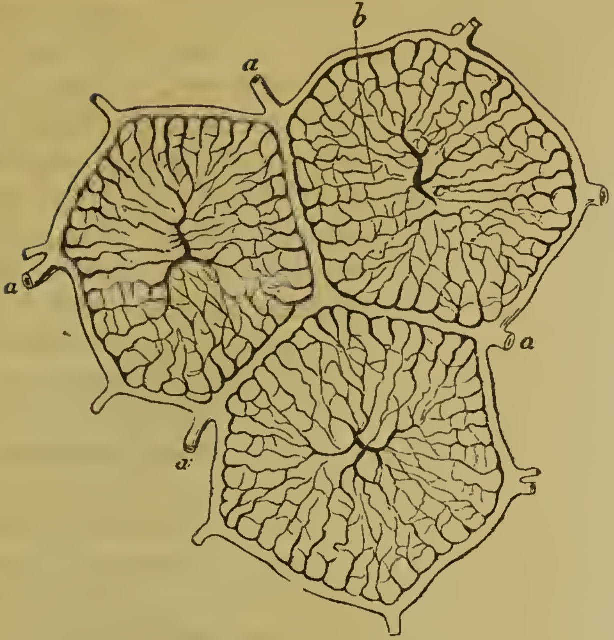
a, Portions of the canal from which the vein is removed to show that it is formed by lobules which present the same appearance with those upon the external surface of the liver. *b*, The side of the portal vein which is in contact with the canal. *c*, The side of the vein which is separated from the canal by the hepatic artery and duct, by the Glisson's capsule surrounding them, and by the vaginal plexus. *d*, The internal surface of the portal vein, through which is seen the outline of the lobules, and the openings of the interlobular veins which correspond with the interlobular spaces. Upon the opposite side (*c*), the portal vein being separated from the portal canal there are no interlobular veins. *e*, The openings of smaller portal veins. *f*, Vaginal veins giving off branches in the portal canal and forming a plexus. *g*, The hepatic artery giving off vaginal branches. *h*, The hepatic duct giving off vaginal branches.

ing interlobular fissures not proceeding so far as to inosculate and form meshes, have a radiated appearance and resemble a number of minute stellæ; these are the *stellated vessels* of anatomists.

The *lobular veins* are derived from the interlobular veins; they form a plexus within the lobule, and converge from the circumference towards the centre, where they terminate in the minute branches of the intralobular vein. "This plexus, interposed between the interlobular portal veins and the intralobular hepatic vein, constitutes the venous part of the lobule, and may be called the *lobular venous plexus*." (*fig.* 39). The irregular islets of the substance of the lobules seen between the meshes of this plexus by means of the microscope are the acini of Malpighi, and are shown by Kiernan to be portions of the lobular biliary plexus.

The portal vein collects the venous blood from the chylopoietic viscera, and then circulates it through the lobules; it likewise receives the venous blood which results from the distribution of the hepatic artery to the structures of the liver; these two sources of supply constitute the two origins of the portal vein, the *abdominal origin* and the *hepatic origin*.

Fig. 39.



Two lobules, in which the portal venous plexus is seen. After Kiernan.

a a, Interlobular veins. The appearance of venous circles formed by these veins is that which is afforded by a common lens; when examined with a higher power the interlobular fissure is seen to be filled by a vascular plexus. *b*, The lobular venous plexus. The circular and ovoid spaces seen between the branches of the plexuses are occupied by portions of the biliary plexus: they are the acini of Malpighi. *c*, The intralobular vein in the centre of each lobule, collecting the blood from the lobular venous plexus.

The *hepatic duct* bifurcates in the transverse fissure into two branches, which enter the right and left lobes of the liver and subdivide into smaller branches, and the smaller branches accompany the divisions of the portal vein and hepatic artery through the portal canals to their ultimate distribution in the lobules. The branches of the hepatic duct, like those of the portal vein, are divisible into the vaginal, interlobular, and lobular ducts.

The *vaginal ducts* pass transversely through the capsule of Glisson, by which they are enveloped in common with the portal vein and hepatic artery, and divide into numerous small branches which assist in forming the *vaginal plexus*. From the plexus of ducts two kinds of branches are given off, the *interlobular*, which run along the margins of the interlobular fissures and enter the interlobular spaces to be distributed upon the capsular surfaces of the lobules; and the *lobular*, which enter the substance of those lobules which form the parietes of the portal canals. In the smaller portal canals the vaginal branches and plexus are situated only on the portal side of the canal, the interlobular branches, on the side nearest the duct, passing directly into the interlobular spaces. "The transverse branches and those which arise immediately from them do not anastomose with each other, but the smaller branches sometimes appear to do so; I cannot, however," says Kiernan, "from dissection, affirm that they do, for those which appear to anastomose are exceedingly small vessels and meet each other at the spaces, hence it is difficult to ascertain whether they really anastomose or enter the spaces together without anastomosing."

The *interlobular ducts* ramify upon the capsular surface of the lobules with the branches of the portal vein and hepatic artery. Kiernan finds these ducts to communicate freely with each other, for he says, "If the left hepatic duct be injected with size or mercury, the injection will return by the right duct without extravasation and without passing into other vessels, and the injection will be found in the interlobular and vaginal ducts as well as in the trunks. This communication between the two ducts does not take place like that which exists between the right and left arteries through the medium of the vaginal branches of the transverse fissure, the injection being found in interlobular branches arising from the right duct. From this experiment, which I have frequently repeated with the same result, it appears that the right and left duct anastomose with each other through the medium of the interlobular ducts. This experiment does not always succeed, which probably arises from the quantity of bile contained in the ducts."

The *lobular ducts* entering the lobule by its circumference divide and subdivide into minute branches which anastomose with each other and form a "reticulated plexus," the *lobular biliary plexus* (*fig.* 40). This plexus constitutes the principal part of the substance of the lobule, and seen through the meshes of the portal venous plexus, gives rise to the appearance of acini or of cœcal terminations of ducts. The ultimate terminations of the ducts have not yet been seen; they are imagined by Müller to end in "short pannicle-like tufts closely interwoven together," and he supports his opinion by citing the circumstance of the ducts in the embryo of the fowl and larva of

Fig. 40.

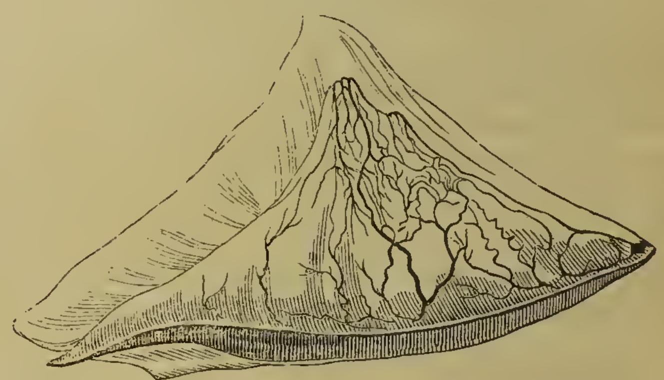
Two lobules in which the lobular biliary plexus is shewn. After Kiernan.

a a, Interlobular ducts giving off branches which form the plexus within the lobules. The central portion of the lobules is uninjected. *b b*, The ramifications of the intralobular veins. With regard to this figure Kiernan observes, "No such view of the ducts as that represented in this figure can be obtained in the liver. The interlobular ducts are in the figure seen anastomosing with each other. I have never seen these anastomoses, but I have seen the anastomoses of the ducts in the left lateral ligament, and from the results of experiments related in this paper, I believe the interlobular ducts anastomose. I have never injected the lobular biliary plexuses to the extent represented in the figure."

the frog ending in twig-like terminations. Kiernan inclines to the opinion that they terminate in loops, although he says nothing which could lead us to suppose that he rejects the possibility of their terminations being cœcal. Both authors agree that they end by closed extremities. It is this plexus which constitutes the true glandular portion of the liver.

Müller, in reference to the terminations of the ducts in anastomosing plexuses, states, that the history of the development of the organ is opposed to the belief in the existence of anastomoses. Certainly, if we are to credit the principle which he himself has established for the development of glands, viz. that "however various the form of the elementary parts, all secreting glands without exception follow the same law of conformation," the same process must take place in all; and analogy would lead us to infer that a plexiform anastomosis would be the arrangement of the terminal ducts in so complicated a gland as the liver of the adult, whatsoever it may happen to be in the undeveloped organ of the embryo. That there is nothing irrational in this opinion we would turn for proof to another page of his Physiology, where he observes, "in the scorpion, as I have discovered, the tubes (of the testis) *anastomose*, forming loops." Again, he says, "Lauth has but once seen a seminal canal ending with a free extremity in the human testis. Krause has seen such free ends of the tubuli seminiferi frequently, and confirms the opinion of their terminating in that way as well as by anastomosis. Lauth attributes the circumstance of free extremities of the tubes being so seldom seen to their uniting with each other so as to form loops. He describes the division and reunion of the tubes to be so frequent that in a small portion which he spread out, and in which there were about forty-nine inches of tube, he found about fifteen anastomoses. It is, however, only towards their extremities that the seminal tubes anastomose thus freely. The discovery of the anastomoses of the seminal tubes is perfectly original." Krause observes the same fact also with regard to the uriniferous ducts. Now I would ask why, if the ducts of the seminal gland and uriniferous gland anastomose so freely, the ducts of the biliary gland should not do the same? And why, if the anastomoses of the seminal ducts be a discovery *so original*, the less easily demonstrable fact of the anastomoses of the biliary ducts, discovered by Kiernan, may not be equally original? I speak from laborious research upon this subject, and surely there cannot be a comparison between the difficulty of unravelling the simple ducts of the testis and the complicated and minute masses of the biliary ducts, an aggregation so intricate that Müller acknowledges it "difficult to decide the question." The above facts of the anastomoses of the seminal and uriniferous ducts would, in my mind, were other evidence wanting, be a circumstance powerfully aiding my belief in the anastomoses of the biliary ducts; but the subject is not without its proofs, and these, as it appears to me, from careful examination, incontestible. "The left lateral ligament," says Kiernan, "may be considered as a rudimental liver, in which this organ presents itself to our examination in its simplest form. From that edge of the liver connected to the ligament, numerous ducts emerge, which ramify between the two layers of peritoneum of which the ligament is composed." "These ducts, the smallest of which are very tortuous in their course, divide, subdivide, and anastomose with each other. They are sometimes exceedingly numerous, two or three of them in such cases being of considerable size; some of them, as Ferrein" (by whom they were discovered) "says, frequently extend to the diaphragm and ramify on its inferior surface. They sometimes extend only half way up the ligament, where they divide into branches, which forming arches (*fig.* 41,) return and descend towards the liver,

Fig. 41.



*The left lateral ligament, in which are seen the injected biliary ducts with their anastomoses. After Kiernan.**

anastomosing or being continuous with other ducts issuing from it. The spaces between the larger or excreting ducts are occupied by plexuses of minute or secreting ducts." "Branches of the portal and hepatic veins, with arteries and absorbents, also ramify in the ligament, which, including between its layers a plexus of secreting and excreting ducts, with bloodvessels ramifying on their parietes, admirably displays the structure of the liver." The same appearances are seen in the bands which sometimes arch over the vena cava and longitudinal fissure, when they are sufficiently thin.

The hepatic ducts are extremely vascular, and in a well-injected liver are always completely covered with the ramifications of the hepatic artery. The rugæ upon their internal surface are formed by large vessels, "arteries as well as veins," which are distributed beneath the mucous membrane. This membrane, seen beneath the microscope, appears plaited over every part of its surface by innumerable laminated papillæ of a semilunar form. The vessels distributed upon these papillæ consist of an artery which ascends upon each side of the lamina, and divides into a beautiful net-work of capillaries which are collected after their distribution into a small vein and returned to the portal vein. "It is," says Kiernan, "to the rupture of the delicate vessels forming these

* I have carefully examined this preparation and pledge myself to its accuracy.

papillæ that is to be attributed the facility with which Söemmering and other anatomists injected the ducts from the arteries and veins, and not to any direct communication between the vessels and the ducts."

The mucous lining of the ducts is provided with a considerable number of muciparous follicles which mingle their secretion with the bile during its passage along the excretory tubes. These follicles have been described by all anatomists as existing in the larger ducts, but they were not known to be present in the smaller branches until they were discovered and figured by Kiernan. In the larger ducts they are irregularly dispersed, but in the smaller tubes are found arranged in two longitudinal rows upon opposite sides of the ducts. Hence the vascularity of the hepatic ducts is intended to perform a higher function than the mere nutrition of those tubes; it provides an important secretion as an auxiliary to the composition of the bile.

The *hepatic artery* arises from the cœliac axis and ascends through the right border of the lesser omentum to the transverse fissure of the liver, where it bifurcates into two branches for the right and left lobes. The right and left hepatic arteries ramify in the portal canals, and give off branches which accompany each twig of the portal vein and hepatic duct. Their branches, like those of the vein and duct, are the vaginal, the interlobular, and the lobular.

The *vaginal arteries* arise from the hepatic arteries in the portal canals, and assist in forming the vaginal plexus in the capsule of Glisson, from which the interlobular branches are given off to accompany the interlobular portal veins and ducts. In the larger canals the plexus completely surrounds the portal vessels, but in the smaller canals the plexus is situated only on the side opposite to the cylinder of the artery, and in the tissue of Glisson's capsule. This vaginal plexus has the effect of supplying the lobules which are the most distant from the vessel to which they belong, as certainly, as those which are in immediate contact with its cylinder. The vaginal arteries anastomose so freely with each other, that if the hepatic artery of one side be injected, the injection will return by that of the opposite side.

The *interlobular arteries* enter the intervals of the lobules through the interlobular spaces and ramify upon the capsular surface of the lobules. They are distributed principally to the interlobular ducts, around which they form a vascular net-work. The question of the inosculation of these vessels is very difficult to decide by dissection on account of their extreme minuteness; but analogy would lead us to infer that they must communicate.

The *lobular arteries*, " exceedinuly minute and few in number," so as to be demonstrable with much difficulty in the structure of the lobules, enter the circumference of these bodies with the lobular ducts upon which they are distributed. They are the nutrient vessels of the lobules, and terminate in the lobular venous plexus formed by the portal vein.

The mode of distribution of the hepatic artery is a subject upon which some difference of opinion subsists between Müller and Kiernan. Kiernan states that the hepatic artery is distributed chiefly upon the coats of the ducts and gall-bladder, upon the coats of the other vessels to which it forms the vasa vasorum, and to the substance of the lobules. The ducts are highly vascular, and are abundantly supplied, the lobules sparingly, but " few" vessels, and those " exceedingly minute," being traceable into them. From the capillaries of the ducts and vessels, the blood having become venous during its circulation is returned into the portal vein, and thence conveyed onwards to the lobules, where it is distributed through the lobular venous plexus. The blood of the terminal lobular arteries also becomes venous in the substance of the lobules, and is likewise poured into the lobular venous plexus. So that, according to this author, the whole of the blood distributed through the hepatic artery is received by the portal vein, either in the course of that vessel, or at its termination in the lobular venous plexus, and therefore, that all the blood circulating through the plexus must necessarily be *venous*. He likewise affirms that no part of the blood of the artery is poured directly into the hepatic vein. " The intralobular veins," he says, " convey the blood from the lobular venous plexus, and not from the arteries." These views are the results of the evidence of numerous experimental injections. With regard to the vascularity of the lobules, he observes, " These bodies cannot be coloured with injection from the artery, even in the young subject; in the adult, after the most successful injection, when the arteries of the cellular capsule, those of the excreting ducts and gall-bladder, and the vasa vasorum are minutely injected, a few injected vessels only are detected entering the lobules. I have frequently tied the thoracic aorta in living animals, thereby cutting off all supply of blood from the abdominal viscera; and in these animals, when injected from the aorta below the ligature forty-eight hours after death, the integuments, the secreting portions of the kidneys, the spleen, pancreas, intestines, and pelvic viscera were coloured in a remarkable degree by the injection; on the surface of the liver a few vessels only could be discovered, this organ presenting a curious contrast with the surrounding coloured viscera. The gall-bladder and ducts were, however, equally well injected with the intestines; the vasa vasorum were also well injected." Perceiving in the progress of his experiments that the injection thrown into the artery passed freely into the portal vein by means of the capillary communication existing between these two vessels on the coats of the ducts, and through the vasa vasorum of the vessels, he imagined that the injected fluid might in this way be diverted from the lobules, and that this must be the cause of his want of success in filling the lobular arteries. To ascertain if such were the case, he injected the portal vein in the first instance with blue, and then the arteries with red. " On dissection, branches of the two sets of vessels were found in the coats of the

vessels, and in those of the excreting ducts and gall-bladder; the lobules were coloured with the blue injection; the red was confined to their circumference, and appeared in points only. This experiment was varied by injecting the portal vein and its branches as far only as the entrance of the latter into the lobules, the lobules thus remaining uninjected. The injection propelled through the arteries had now free access to the uninjected lobules, and no exit by the injected portal vein; and the artery having no communication with the hepatic veins, the injection had no exit by these vessels: the lobules however were not better injected in this than in the preceding experiments. From these experiments I conclude, that the secreting part of the liver" "is supplied with arterial blood for nutrition only. As all the branches of the artery of which we can ascertain the termination, end in branches of the portal vein, it is probable that the lobular arteries terminate in the lobular venous plexuses formed by that vein, and not in the intralobular branches of the hepatic veins, which cannot be injected from the artery." Müller, who published upon this subject previously to the discoveries of Kiernan, and was therefore not aware of the exact distribution of the vessels, was deceived by this free communication between the hepatic artery and portal vein. He conceived, with the older anatomists, that the arterial blood was mixed with the venous blood of the vena portæ, in a capillary network, "vascula ultima reticulata," common to the three bloodvessels of the liver, the hepatic artery, portal vein and hepatic veins. Observing, moreover, in the injected preparations of Lieberkühn,* that the "vascula ultima reticulata," the lobular venous plexus of Kiernan, appeared as well filled when the injected fluid was forced into the hepatic artery, as when introduced through the portal or hepatic vein, he at once decided that the artery must pour its blood directly into this plexus. Hence he writes, "Vascula ultima reticulata sanguinem tam ab arteriis quam a venâ portarum accipere, venisque hepaticis reddere, ex hisce argumentis concludo: Post injectionem in arteriam hepaticam non minus quam in venam portarum aut venas hepaticas factam, eadem communia vasculorum minimorum retia replentur, quod ex injectionibus exsiccatis Lieberkühnianis, Berolini asservatis, facile quisquis sibi persuadebit." Having recourse himself to an extremely imperfect experiment, the injection of water into the hepatic artery, and finding that this fluid returned by the portal vein, and possibly by the hepatic vein, he became convinced of the communications of all the vessels in the "vascula ultima reticulata," and added another argument to the injections of Lieberkühn in favour of his opinion; for he says, "Injecti liquores colorati ex alio vasorum ordine facile in alium transeunt, qualis frequens Halleri veterumque, Walteri, denique et Rudolphi cel. extat experientia. Ipse equidem transitum aquæ limpidæ et coloratæ sæpius observari." Now with regard to the injections of Lieberkühn, I can only repeat with Kiernan, that *if* the lobular venous plexus or "vascula ultima reticulata" were filled, actually, from the artery, the only route which the injection could have taken must have been through the capillaries of the excretory ducts and vasa vasorum, and then through the portal vein. But with regard to the water experiment, I am quite satisfied of its utter inadequacy to elucidate so delicate a point as that under discussion. In my own experiments, made with a view of assuring myself of the nature of these plexuses, I have not been content with my injection unless I could distinctly trace with the aid of the microscope each capillary vessel from the interlobular vein to the intralobular vein, and this I have never failed to do in a successful injection from the portal vein; or in the opposite course when the hepatic veins have been filled. But in the most successful injection from the artery, when the capsular arteries have been beautifully filled, I have never observed more than a few red points in the circumference of the lobules. There is, however, in the consideration of this question, one circumstance which appears to have been altogether overlooked by Müller, but which seems to me to be fatal to the opinion which he entertains with regard to the distribution of the arterial blood. The ducts are abundantly supplied with blood from the arteries; indeed to so great an extent, that in a well-injected liver their coats appear to consist almost wholly of the ramifications of minute vessels. Now if the aggregate of the surface formed by the ducts, which is thus covered with vessels supplied from the artery, be considered, it must be evident that very little can be left for the "vascula ultima reticulata." And if conjointly with this fact, the difficulty of injecting the lobules from the artery be considered, it must be admitted that Müller carries his dogma somewhat too far, in asserting without limitation "that the arterial blood of the hepatic artery and the venous blood of the porta become mixed in the minute vessels of the liver."

The *hepatic veins* return the whole of the venous blood from the liver to the general venous circulation. They commence in the centre of each lobule by means of a small vein, the *intralobular*, which collects the blood after its circulation through the lobular venous plexus. The intralobular veins pour their current into the *sublobular* veins, and these latter unite to form the hepatic trunks, which terminate in the inferior vena cava. The hepatic differ from the portal veins in being more immediately in contact, and more closely connected with the substance of the lobules. Thus the intralobular veins are embedded in the substance of each lobule, and the sublobular inclosed in canals formed by the bases of the lobules, and therefore by that part which is uninvested by the lobular capsule. The hepatic trunks differ

* Having, through the kindness of Mr. Liston, had an opportunity of examining with the microscope some of the injections of Lieberkühn of different tissues, I can bear testimony to their beauty and wonderful minuteness, and can fully appreciate the deservedly high estimation in which they are held among the physiologists of Germany.

from the preceding in being lodged in canals formed by the capsular surface of the lobules, the *hepatic venous canals,* which are analogous to the portal canals excepting in the absence of a proper investment of Glisson's capsule. It follows from this circumstance, that there are no vessels in connection with the hepatic veins at all resembling the vaginal branches and plexuses of the portal vein. The general course of the hepatic veins is from the two surfaces and free margin of the liver towards the vena cava in the posterior border; that of the portal vein radiates from the transverse fissure in the centre of the under surface to all parts of the circumference; hence the two veins cross each other in their course, the former proceeding from before backwards, and the latter from the centre towards the circumference. In examining either of these sets of vessels, we should, therefore, be guided in the direction of our section by this peculiar arrangement. There is another mode by which we arrive at a knowledge of the means of discriminating between the two veins in a section. The hepatic vein being closely adherent to the lobules forming the canal in which it is lodged, remains open, and retains the form of its cylinder upon the face of a section; it may also be recognised by being solitary. The portal vein, on the contrary, being surrounded by the loose, vasculo-cellular web of Glisson's capsule, is permitted to collapse; it is also characterised by being associated with a branch of the hepatic artery and duct. In the consideration of the hepatic veins I shall describe, first, the intralobular, next the sublobular, and then the hepatic trunks.

In the centre of each lobule is situated an *intralobular vein* (*fig.* 34, 5,) which is formed by the convergence of from " four to six or eight" minute venules, from the processes upon the surface of the lobule. In the superficial lobules, the intralobular vein commences directly from the surface, and the minute venules by which it is formed may be seen in an ordinary injection converging from the circumference towards the centre. The vein then takes its course through the centre of the longitudinal axis of the lobule, and piercing the middle of its base opens into the sublobular vein. The intralobular veins have no direct communication with the portal vein or with the hepatic artery, and they simply serve to collect the blood which has circulated through the lobular venous plexus, and convey it into the general current of the hepatic veins.

The *sublobular veins* (*fig.* 34) are named from their position at the base of the lobules. They are lodged in canals which are formed by the bases of all the lobules of the liver. They are extremely thin and "delicate in texture," and lie in close contact with the substance of the lobules, so that upon laying open one of these veins, the bases of the lobules may be seen distinctly through its coats. In the centre of the base of each of the lobules will be observed the opening of the intralobular vein, so that the whole internal surface of the vein is pierced by these minute openings. In the smaller portal veins, on the other hand, where a number of small foramina were seen upon the internal surface of that side of the vessel which lay in contact with the canal, and where the outline of the lobules was also perceptible, it was observed that the small openings corresponded with the interlobular spaces, and were the entrances of the interlobular veins.

The *hepatic trunks* receiving the blood from the sublobular veins take their course along the "hepatic venous canals," and terminate by two large openings corresponding with the right and left lobes in the inferior cava, at the point where that vessel is lying deeply imbedded in the posterior border of the liver. A number of minor hepatic veins also terminate in the cava at this part of its course. The *hepatic venous canals* resemble the portal canals in being formed by the capsular surfaces of the lobules, lined by a prolongation of the proper capsule. The hepatic trunks are thick and dense in their structure, and their external coat is composed of "longitudinal bands." From the thickness of their texture the outline of the lobules is not apparent through their coats, nor have they any intralobular veins opening into them.

The coats of the hepatic veins are supplied with blood by the hepatic artery, and the venous blood is returned to the ramifications of the portal vein.

The *lymphatic* vessels of the liver are divisible into the deep and superficial. The former take their course through the portal canals, and through the right border of the lesser omentum, to the lymphatic glands situate in the course of the hepatic artery, and along the lesser curve of the stomach. They are easily injected (by rupture of course) from the hepatic ducts, and Kiernan remarks, that " injection sometimes passes from the arteries and portal veins into the lymphatics. I have frequently seen them in the right border of the lesser omentum, when distended with injection, as large as small veins. The *superficial lymphatics,* (*figs.* 32 and 33,) are situated in the cellular structure of the proper capsule, over the whole surface of the liver. Those of the convex surface are divided into two sets; 1st, those which pass from before backwards; and 2d, those which advance from behind forwards. The former unite to form trunks, which enter between the folds of the lateral ligaments at the right and left extremities of the organ, and of the coronary ligament in the middle. Some of them pierce the diaphragm, and join the posterior mediastinal glands; others converge to the lymphatic glands situated around the inferior cava. Those which pass from behind forwards consist of two groups; one ascends between the folds of the broad ligament, and perforates the diaphragm to terminate in the anterior mediastinal glands; the other curves around the anterior margin of the liver to its concave surface, and from thence to the glands in the right border of the lesser omentum. The lymphatic vessels of the concave surface are variously distributed according to their position; those from the right lobe terminate in the lumbar glands;—those from

the gall-bladder, which are large and form a remarkable plexus, enter the glands in the right border of the lesser omentum; and those from the left lobe converge to the lymphatic glands situated along the lesser curve of the stomach.

The *nerves* which supply the liver are derived from the systems both of animal and organic life; the former are filaments of the right phrenic and two pneumo-gastric nerves, and the latter of the solar plexus. The branches from the right phrenic nerve descend by the side of the inferior cava, to unite with the hepatic plexus in the right border of the lesser omentum. Swan describes a small ganglion, to which filaments converge from the right semilunar ganglion and right phrenic nerve, as being the medium of communication between the phrenic nerve and the hepatic plexus. The branches of the pneumo-gastric nerves pass between the two layers of the lesser omentum to its right border, and pursuing the course of the hepatic artery are distributed with the hepatic plexus to the gall-bladder and along the portal canals. The *hepatic plexus* proceeds from the solar plexus and surrounds the hepatic artery to the transverse fissure; its filaments then accompany the branches of that vessel to their ultimate termination, and some few are observed to ramify upon the portal vein.

Progressive development of the liver in the animal series.—The liver in its simplest condition is a mere inflection of the mucous lining of the alimentary canal, forming a small cœcal recess or follicle. The capillary vessels ramifying upon the parietes of this follicle pour their secretion upon its internal surface, and it is thence conveyed to the alimentary canal to be mingled with the ingesta. In this its most rudimentary form the liver would appear to be present in the *Laginella*, a small cilio-brachiate polypus described and figured by Dr. Arthur Farre.* Upon the stomach of the *Laginella* are seen several minute cœca which open into its cavity; they are usually empty when the animal has been for some time without food, but become filled with a brownish fluid after a meal. The next most elementary form of the hepatic cœcum is seen in the single lengthened follicle discovered by Owen in the *ascaris halicoris*. This follicle opens into the alimentary canal at about one-third from its oral extremity. Among the *Annelida*, as in the medicinal leech (*fig.* 69, vol. i.) the liver is represented by numerous simple cœcal pouches appended to each side of the digestive canal. The next step in the complication of the organ is observed in the lengthened filiform tubuli which are connected with the sides of the canal in the Aphrodita. These are narrow and constricted at their commencement, dilating gradually as they proceed farther from the intestine, and terminating by a small oval sac. In other species of the same genus and in the Arenicola (*fig.* 70, vol. i.) they display a tendency to ramify, by developing small cœcal pouches from their sides. In these terminal sacculi Pallas discovered a " bitter fluid, of an olive-brown or greenish-black colour," which he conceived to be the juices of marine plants which had gained admission into the tubuli through their openings of communication with the intestine, but which, it is more than probable, was the proper biliary secretion of the tubes themselves. In the class *Insecta* the hepatic cœca vary in progressive development from the simple vesicular dilatations observed upon the digestive canal of the Lampyrus splendidula, or the simple cœcal tubulus of the carnivorous Cicindela, to the numerous cœcal follicles of the Dytiscus, or to the more lengthened tubuli of the Blatta orientalis. Throughout the whole of the class the character of the liver is tubular, the development and extent of the tubuli depending upon peculiarities in the food or habits of the animals. In *Arachnida*, the cœcal follicles are short, and terminate at their extremities in a cluster of numerous rounded vesicles, which give to the organ a lobulated appearance. They are seen in the Scorpion, in *fig.* 83, *c*, *c*, page 204, vol. i. In the class *Crustacea*, the hepatic organ assumes a higher and more complicated character; the simple cœcal follicle of Insecta becomes branched and ramified, of which we have a good example in the Argulus foliaceus, delineated by Müller. In the Astacus fluviatilis (*fig.* 214, page 483, vol. i.) the hepatic follicle is more branched than in the Argulus; and in the Pagurus striatus (*fig.* 215, page 484, vol. i.) the liver is composed of an extraordinary assemblage of ramified follicles. In the hepatic organ of the Squilla mantis we perceive a remarkable transition from the simple branched and ramified follicle of the lower Crustacea to the higher forms of the organ in the molluscous classes. Upon the exterior it is lobulated, and each lobe is composed of a congeries of minor lobules which appear like granulations upon its surface. Examined in its interior it presents a primary dilated sac of considerable size, from which branch off a number of secondary sacs of smaller dimensions, and these latter are studded over every part of their surface with minute cœcal follicles of a rounded form. In the subregnum *Mollusca* the liver is of large size, and approaches in external form to the solid and lobulated organ of vertebrata. In internal conformation we may still trace among the lower classes a close analogy with the ramified tubuli of Articulata. Thus in the class Gasteropoda the gland is composed of cœcal pouches, which divide and subdivide into smaller and smaller follicles and terminate in small dilated sacs. They may be compared in their disposition to the stem, branches, twigs, and fruit of a cluster of grapes. A liver of this kind is seen in the Helix pomatia. In the Murex triton the follicular structure of the organ would appear to be lost. The external surface presents a lobulated form, but the interior is composed of a delicate spongy tissue, consisting of larger and smaller cells, which may all be inflated from the excretory duct. This seeming difference in the structure

* Philosophical Transactions, 1837.

of the organ is, however, more apparent than real, for the numerous cells may be considered as so many follicles from which smaller follicles are developed. The cellular character of the organ depends upon the more extensive subdivision of the follicles, their assemblage in greater numbers, their consequent compression, and the adhesion of their parietes. In the Sepia family the spongy structure of the hepatic organ is still more distinct. It is channelled into numerous canals, from which smaller canals branch off in various directions; from these branches cells are developed, and the parietes of the cells are every where surrounded by smaller and smaller cells, the entire texture being very similar in arrangement to the cellular lung of the higher reptilia.

The liver in *Vertebrata* is more close and complex in its structure and less amenable to the observations of the anatomist than in the inferior series. We observe nothing, even in the lowest fishes, which bears any direct comparison with the cellular structure of the liver of Cephalopoda. The general character of the organ in fishes is loose and flabby, shewing that, although difficult to demonstrate, its internal texture evidently contains numerous tubuli. If the efferent duct of the liver of a fish be inflated, the whole organ appears distended; hence we might infer that the primitive structure of the organ is precisely the same, consisting in the ramifications of the hepatic tubuli or ducts, the increased wants and higher position of the animal demanding an augmented extension of surface. This is the great principle in the development of all glandular organs—extension of surface. The simple follicle is sufficient for an animal so low in the scale as a cavitary entozoon, but as the functions of the animal increase, its simple follicle must be extended to a greater length, or branched or ramified; and as high in the animal scale as the Vertebrata these subdivisions have attained so great a degree of minuteness that they are demonstrable to the practised eye only through the aid of the highest microscopic powers.

Müller arranges the glandular system into *simple* and *compound* glands. The former he divides into two groups: 1. "*simplest glands*," which "are mere recesses of greater or less dimension in the surface of a membrane;" and 2. "more complicated forms," in which several of the recesses are assembled together and open by so many distinct mouths, or they unite and form a common duct which terminates by a single opening. The "compound glands" he likewise subdivides into two groups: 1. those which "ramify with a certain degree of regularity, the principal trunk giving off branches laterally at certain intervals, these sending out in the same way side branches, which in their turn afford a third set." This disposition constitutes lobulated glands, and is the type of conformation of the liver in Invertebrata. 2. "The second group of the glands with ramified secreting tubes consists of those in which the ramification is irregular, and in which there is no division and subdivision of the gland into" secreting "lobules. The liver of Mammalia belongs to this group."

The form of the liver in *Fishes* corresponds with the direction of the long axis of the body; thus, for instance, it is elongated, and consists of a single lobe in the eel, while in the skate it is broad and extends into each lateral half of the abdominal cavity. In other fishes it is variously divided into lobes, and is often placed altogether on the left side of the body. In the class *Amphibia*, the liver also corresponds with the form of the body of the animal: in the frog it is short and divided into two primary lobes and several lobules; in the lengthened forms it is long and less divided. In the class *Reptilia* the liver is large, and bears an equal relation to the form of the visceral cavity. It is long and undivided in Ophidia, and short and divided into a right and a left lobe in Sauria and Chelonia, the two lobes being spread out over the intestines. In *Birds* there is great uniformity in the form and size of the liver. It is smaller in proportion to the bulk of the body than in Reptilia and Fishes, and larger than in Mammalia. It is situated in the middle line of the visceral cavity, and receives the heart into a depression upon its under surface. In the class *Mammalia* the liver is very much reduced in size, and is more compact and firm than in the lower vertebrata. In animals with simple stomachs it is situated in the middle line of the abdomen. In others, with large or compound stomachs, it is pressed towards the right side. The number of lobes does not depend upon a greater or less division of the liver into parts in accordance with the activity and mobility of the animal, but obeys a law in the animal economy, by which new parts are superadded in proportion to the increase of the wants of the creature. Man is placed at the foot of the scale in the progressive complication in external form of the liver of vertebrata; the entire organ may be considered in him as a central lobe, the lobus Spigelii being the rudiment of a second or right lobe. The liver of the ourang offers the same character. Ruminants have also a liver which presents the most rudimentary form of division. The liver of man is the type of the central or principal lobe, to which are added upon each side, in the animal scale, a right and a left lobe, and from these latter are developed a right lobule and a left lobule. This most complicated form of liver, consisting of five lobes, is met with among Carnivora and Rodentia; and throughout Mammalia, the successive additions and subtractions from this normal type form a constant and generic character. Besides this real division of the liver into five lobes, fissures of various depth are constantly met with, as in man, which give the appearance of a much greater subdivision. These secondary portions are to be looked upon as the mere results of separation, and have no relation with the primitive type. A most extraordinary form of liver is met with in a small rodent animal from Cuba, the Capromys, in which the whole surface is divided by deep fissures into small masses of a triangular and quadrangular form, like the kidney of a bear.

A similar arrangement is seen upon the visceral surface of the liver in the Llama.

The *gall-bladder* is absent in all invertebrata, the efferent ducts of the biliary organ terminating for the most part by several openings in the digestive stomach. In *Fishes* the gall-bladder is observed for the first time in the animal series, but it is not by any means constant in its existence. It is absent in many genera, and in these cases is frequently replaced by a dilatation upon the hepatic duct and by several efferent tubes. In the class *Reptilia* it is invariably present, and varies considerably in form, in the different genera. In serpents it is placed at the extremity or even beyond the liver, and occupies the space formed by the pyloric contraction of the stomach. The cystic duct is consequently extremely long. Among the Chelonia the gall-bladder is enclosed within the substance of the liver, and receives its secretion through the medium of cyst-hepatic ducts. Some of these ducts unite also with the cystic duct and constitute a ductus communis choledochus. In *Birds* the gall-bladder is occasionally absent, as in Pigeons, Toucans, &c. without supplying to the comparative anatomist a sufficient reason for the peculiarity; being present and absent in the same natural genera and under precisely the same circumstances of food and climate. The bile is brought from the liver by two ducts, a cyst-hepatic duct which opens into the gall-bladder, and an hepatic duct which terminates in the duodenum near to the cystic duct. When the gall-bladder is absent, both hepatic ducts terminate in the duodenum. There is no instance in the whole class of a ductus communis choledochus. In *Mammalia*, the gall-bladder is by no means constant; it is deficient as a general rule, to which there are several exceptions, in herbivorous animals, as in the horse, stag, elephant, peccary, tapir, whilst it is present in the ox, sheep, goat, antelope, &c. In the first giraffe examined in this country by Owen it was absent; in the next he found two. Upon the hepatic duct in the elephant, near to the duodenum, there is a remarkable dilatation. In the cat and seal the ductus communis choledochus is dilated in the same situation. It is not uncommon to find a double gall-bladder or two gall-bladders in the cat; in the kinkaju this is supposed to be the normal condition; and in the Museum of the Royal College of Surgeons there is a preparation, preserved by Hunter, of the liver of a small animal in which are three gall-bladders.

Throughout Invertebrata the bile is secreted from arterial blood. In Fishes the portal vein is formed by veins returning from the tail and occasionally from the air-bladder and genital organs. In Reptiles a part of the blood from the lower extremities unites with that from the alimentary canal to constitute the portal circulation. In Birds the portal vein also receives a part of its blood from the tail and lower extremities by means of its communication with the pelv.c veins. (*Fig.* 171, *u*, *v*, *z*, page 338, vol. i.) Injections of the portal vein carefully conducted, as well as injections from the internal iliac vein, have shewn that a venous communication subsists between the smaller branches of the two systems in the large intestines, even in man. In support of this communication Müller, in his Physiology, quotes the observations of Retzius: "Professor Retzius, of Stockholm, however, has informed me that he has discovered in man some minute communications between the veins of the intestines and the branches of the vena cava. When he injected the vena cava and vena portæ with fine injection of different colours, he found that the whole meso-colon and colon sinistrum were injected with both colours, and veins belonging to the two systems at several places formed anastomoses. The veins of the colon and meso-colon, which belonged to the system of the vena cava and entered the left renal vein, lay superficially, while those which belonged to the vena portæ lay for the most part nearer the mucous membrane. The external surface of the duodenum also had received injection from the vena cava. M. Breschet too has filled the inferior mesenteric vein from branches of the inferior cava, and Schlemm has discovered distinct communications of the inferior mesenteric vein with branches of the inferior cava about the anus." Besides these communications between the two systems occurring in the pelvis, Kiernan points to another most important communication upon the surface of the liver. "The capsular veins," he says, "are branches of the portal vein; these vessels communicate freely with branches of the phrenic veins. In some cases of atrophy of the liver, and in cases in which the circulation through the liver has been for some time obstructed, a collateral circulation is established by means of the communications which take place between the capsular branches of the hepatic artery and portal vein and those of the phrenic artery and vein." In diving animals, as in the otter and seal, in which large venous reservoirs exist upon the inferior cava, for collecting the returning blood during submersion, the hepatic veins are muscular. Kiernan observes with regard to the hepatic veins of the seal that they "differ in many respects from those of any other animal I have examined. The intralobular veins at their exit from the lobules do not as in other animals terminate immediately in the hepatic veins: these vessels enter the hepatic venous canals, where they unite into branches, which, like the vaginal branches of the portal vein, are connected by a fine cellular tissue, with which they form around the hepatic veins a cellulo-vascular sheath precisely similar to that surrounding the branches of the portal vein. The structure of the two sheaths is similar, but their uses are different. That of Glisson's capsule has been explained; the capsule of the hepatic veins in the seal appears destined to admit of the muscular contractions of these vessels." "The external coat of the hepatic veins is composed of circular fibres which in the larger vessels form a complete tunic. In the smaller vessels the fibres are arranged in the form of circular fas-

ciculi, which are connected with each other by oblique intermediate fibres. All the fasciculi do not extend completely round the veins; some, dividing into two portions, unite with fibres from those above and below, and form other fasciculi." "In the porpoise the hepatic veins are connected to their canals; no circular fibres are seen in their coats. Their external surface is reticulated, the ridges corresponding to the interlobular fissures, where the interlobular cellular tissue is continuous with the cellular coat of the veins. The mouth of an intra-lobular vein occupies the centre of each space circumscribed by the ridges."

The distribution of the vessels in the liver in the three great classes, Reptilia, Aves, and Mammalia, has been ascertained to be the same with that which has been so completely illustrated in the discoveries of Kiernan. In Fishes but few observations have been made, but analogy would lead us to infer that the general arrangement must be the same.

Development of the liver in the embryo.— The development of the liver in the embryo commences so early in Mammiferous animals, hurries so rapidly through its different phases, and is completed so soon, that it has hitherto been impossible to obtain any connected and precise information with regard to its progress. The observations of eminent physiologists made from time to time have, however, shewn that the mode of its development is in all respects similar to the development of the liver in the chick. Indeed, the egg of the bird is in the highest degree favourable to anatomical examination, both on account of its large size and the facility with which the incubated egg may be obtained from hour to hour, and from day to day. The principle of development therefore being the same in the ovum of the bird as in Mammifera, I shall here trace the progress of the liver in the chick according to the most recent researches of Baer.

In the embryo of the fowl at the commencement of the third day, the common vein of the body is embraced by two pyramidal cœcal pouches which communicate by their bases with the intestinal canal, and which shoot forwards so as to carry before them a fold of the vascular layer of the germinal membrane, in which they begin to ramify by giving off cœcal branches from their sides and extremities. These two cœcal tubuli with their corresponding ramifications form two flattened processes, which represent the two lateral lobes of the liver. By the end of the third day the two processes resemble folds of the vascular layer in which the tubuli are seen ramifying; they have increased in size and almost surround the vein. On the fourth day the liver has the appearance of two flattened processes which enclose the vena portæ. The hepatic tubuli have become lengthened and further removed from the intestine, and have ramified more freely in the vascular layer. By their bases the hepatic tubuli approach nearer to each other, and at the end of the fourth day they coalesce and form a common tube. On the fifth day the liver has attained considerable size; its two lobes have become thick and appear to possess a spongy texture in their interior. The hepatic ducts are connected with the intestine by a common duct, the ductus communis choledochus; and the portal vein gives off large branches which are distributed among the ramifications of the ducts. On the sixth and seventh days the liver receives an abundance of blood and is nearly as red as the auricle of the heart. The left lobe is sensibly smaller than the right. On the eighth, ninth, and tenth days the liver has lost its great redness and presents a yellowish brown tint; the vessels have diminished in calibre, while the parenchyma has increased, and the gall-bladder has become apparent. The succeeding days augment the size of the organ, and mould it to the form which it possesses after the escape of the chick from the egg; it begins to secrete bile; and the gall-bladder assumes the pyriform shape which it retains in after-life.

In the human ovum the formation of the embryo commences visibly at about the third week of intra-uterine existence; the parietes which separate the embryo from the ovum begin to be developed, and rudiments of the intestinal canal, the liver, and the heart soon become distinctly visible. Upon its earliest appearance the liver is of large size, and between the third and the fifth week is one-half the weight of the entire body, divided into several lobes of a reddish grey colour, and receives a large proportion of blood from the omphalo-mesenteric vein. From the fifth to the eighth week the liver extends as low as the margin of the pelvis; it is soft, almost pulpy, and greyish in colour. The gall-bladder is developed in the form of a lengthened filiform cord, having an extremely minute canal through its centre. By the third lunar month the liver extends nearly to the pelvis and almost fills the abdomen, and the right lobe has increased somewhat beyond the left. The texture is more firm and of a redder colour, and the gall-bladder is long and conical. At the fourth lunar month the liver is still prolonged nearly to the margin of the pelvis, but the left lobe is evidently shorter than the right. The gall-bladder is elongated, straight, and vertical in direction, and contains a little mucus. Upon its internal surface a few rugæ begin to be perceived; it receives no bile, although a small quantity of that fluid is secreted by the liver and poured into the intestine. By the fifth lunar month the liver has acquired an increased consistence and deeper colour. It no longer descends so low as the pelvis, but appears to have diminished in bulk in proportion with the size of the abdomen. The gall-bladder assumes a more horizontal direction, and the contained mucus has a yellowish green tint. The openings of the ductus choledochus and pancreatic duct, at first placed at a considerable distance from each other, approximate and produce less projection of the mucous membrane. By the sixth lunar month the descent of the liver is still more curtailed, the fœtus increases in development from before backwards, and the organ becomes more horizontal. By the seventh lunar month

the gall-bladder contains bile, and the mucous membrane becomes rugous and reticulated. At the eighth month, and during the ninth and tenth months, the liver becomes still more horizontal in position and of a deep red colour. The bile is more abundant and of a clear green tint. At the tenth month, that is, at birth, the relative proportion of the liver to the rest of the body is as 1 to 18 or 20; the average in the adult being as 1 to 36. After birth the size and weight of the liver diminish until the end of the first year, for, according to Meckel, the liver of the newly born infant weighs one-fourth heavier than at the age of eight or ten months. The borders of the liver are rounded in the fœtus, and the inferior surface is convex. The lobes are nearly equal until birth, after which the left diminishes in size, the right remaining stationary or growing but little, and at the age of one year the left lobe is scarcely one-half so large as at birth. The texture of the liver in the fœtus is soft and fragile and apparently homogeneous in structure; during the earlier periods its colour is a light brownish grey; at about the mid-period it becomes deeply red, and after birth loses a portion of its colour from a diminution of the quantity of blood circulating through it.

Uses of the liver.—The liver performs two most important functions in the animal economy:—1, it separates from the venous blood of the chylopoietic viscera certain elements which are needful to digestion; and, 2, it depurates the venous blood. The first of these functions constitutes the secretion of bile. The second is evinced in a comparative examination of two of the great depurating organs, the lungs and the liver, in the various classes of animals, where the latter will be constantly found in exact relation with the development of the respiratory organ, and with the necessity for the removal of a larger quantity of hydrogen and carbon from the blood. Thus, in herbivorous animals, the liver is small; it is small also in monkeys and in man. It is large, and has reached its highest development amongst Mammiferous animals in Carnivora. In birds it is larger in proportion than in Carnivora, from the greater necessity of a highly oxygenated blood in that class of animals. In Reptiles, with cold blood and a low degree of respiration, it is large; it is large also and for the same reason in Fishes; and very large among the Invertebrata.

Secretion of bile.—The bile, which would appear, from the existence of follicular recesses in the alimentary canal, to be produced in all animals from the lowest to the highest, is secreted in man and in vertebrata from the blood during its circulation through the lobular venous plexus in the lobules of the liver. Hence it becomes a question of importance to physiology to decide from what kind of blood it is eliminated. If, according to Kiernan, all the arterial blood of the hepatic artery become venous previously to its passage into the lobular venous plexus, *the bile must be secreted from venous blood;* that venous blood being derived from the capillaries of the chylopoietic organs, and from the capillaries of the hepatic artery. I have given Kiernan's reasons for the belief that this is the truth; and in corroborating the results of his injections I must also add my own testimony to his view of the secretion of the biliary fluid. Müller, entertaining, as I have already shewn, a different opinion with regard to the distribution of the vessels of the liver, believes that the bile is secreted from a *mixed arterial and venous blood,* resulting from the termination of both the hepatic artery and portal vein in the "vascula ultima reticulata," or lobular venous plexus. From the undecided manner in which he expresses this opinion, I am tempted to give the quotation in which it is contained, that my readers may judge how far he be really in earnest in his assertion. "It is known that injection thrown either into the hepatic artery or into the portal vien, fills the same capillary net-work, from which, on the other hand, the hepatic veins likewise arise."

Since reading the above paragraph I have injected twelve livers for the purpose of deciding the question, in my own mind, of the ultimate termination of the hepatic artery; but I have in no instance succeeded in forcing injection into the lobular venous plexus, although every other part of the organ has been beautifully injected. I have therefore been forced to the conclusion that some mistake must exist with regard to this passage, and that, although perfectly true when confined to the portal vein, Müller cannot mean that the capillary network (lobular venous plexus) from which the hepatic veins arise, is actually filled from the *hepatic artery.* But he continues, "It appears, therefore, that the arterial blood of the hepatic artery, and the venous blood of the porta, become mixed in the minute vessels of the liver, and that the secretion of bile *probably* takes place from both." Now, with deference to Müller's judgment, the question, with our present knowledge upon the exact anatomy of the liver, ought not to be one of probability or surmise;—does it? or does it not? But he appears far from satisfied, in relying for the support of his argument upon his own peculiar theory of the arrangement of the hepatic vessels, and, as if distrusting its efficiency, he exclaims in another page of his Physiology, "But the possibility of bile being secreted from arterial blood is demonstrated by the cases in which the vena portæ enters the vena cava directly instead of being distributed through the liver. Mr. Abernethy observed this anomalous structure in a male child ten months old; and Mr. Lawrence has detailed a case in which the same malformation existed in a child several years of age. In Mr. Abernethy's case however the umbilical vein was still pervious and branched out in the substance of the liver; it is possible therefore, as Mr. Kiernan remarks, that the arterial blood, after having nourished the liver, was poured into the branches of the umbilical vein, just as it is in the normal condition, according to his opinion, poured into

branches of the portal vein, and the secretion of bile therefore might still have been derived from venous blood."

"M. Simon and Mr. B. Phillipps have inferred from experiments which they performed, that the bile is secreted from the blood of the portal vein. But Mr. Phillips found that after the vena portæ had been tied the secretion of the bile still continued, though in diminished quantity; and he concludes, therefore, that it is formed both from arterial and venous blood. He perceived no change in the biliary secretion when the hepatic artery was tied."

The cases recorded by Wilson, Abernethy, and Lawrence are interesting, but they do not appear to me to affect in the slightest degree the arguments on either side of the present question. It is true that it might be asserted in behalf of Müller's opinion, that the blood sent to and circulating in the liver was arterial, and that from this alone bile was secreted, for in both cases bile was found in the gall-bladder, while the vena porta emptied itself into the vena cava. On the other hand it was ascertained by Kiernan in the only one of the three cases in which the liver was preserved, that the umbilical vein (hepatic portal) was pervious, of considerable size, and ramified as usual through the portal canals and terminated as usual in the lobular venous plexus. Now, although the hepatic portal vein (umbilical) did not obtain its accustomed supply of blood after the placental circulation was arrested, from the abdominal portal vein, yet there is no reason for supposing that it did not collect the venous blood from the capillaries of the arteries supplying the coats of the excretory ducts and other vessels. Again, the transmission of the remaining portion of the arterial circulation through the vaginal, the interlobular, and lobular arteries must have seriously affected its arterial character if it have not indeed altogether converted it into venous blood. Although Mayo, who took part in the examination of this liver, observed upon this point that "it cannot be supposed that the arterial blood, in its passage through the vasa vasorum into the branches of the umbilical (hepatic portal) vein underwent the usual change into venous blood; and it was still, he contended, arterial blood, though less pure in character, which was conveyed through venous canals into the secreting part of the liver."

Now it may be fairly presumed that blood which is not arterial must be venous; but it must at the same time be admitted that the normal degrees of arterialisation are various in individuals, and different in different regions of the body at the same moment; so that no satisfactory argument can be sustained upon an assumption of the sub-arterial character of the blood. I would rather suggest another train of reasoning. The abdominal portal vein returning blood possessed of peculiar properties from the chylopoietic viscera terminates in a rare anomaly in the inferior cava, so that the portal blood is mingled with the general venous current of the system. The lungs receiving this blood exert their appropriate influence in separating from it a portion of the noxious elements with which it is combined; but it cannot be supposed that this blood will return to the heart as pure in character as that which has circulated in the usual way through the other depurating organ, the liver. No; it still contains the elements from which bile may be secreted, and a larger portion than usual is therefore sent to the liver, that this secretion may be eliminated. Hence we cannot treat the blood thus flowing into the liver from the aorta in a much larger current than natural (" in ordinary cases one principal artery is found in each canal; in this case two, and in some places three arteries of equal calibre were found in each canal") as mere arterial blood destined for nutrition alone; but we must regard it as a fluid bearing in its course the elements of the bile; and therefore, whether it be poured through the capillary channels of the lobular venous plexus, or through those of its own developing in the substance of the lobules, it is nevertheless an abnormal influence which cannot be tested by man's decision, but is part of the compensating principle so admirably displayed by nature in all her operations.

With regard to the evidence of experimental operations upon living animals, this must at all times be unsatisfactory and inconclusive from the difficulty of observing and appreciating the consequences of the experiment, and from the morbid condition impressed upon the animal by the serious nature of the operations themselves Those which have been performed are favourable to the conclusion that the bile is separated from the blood of the portal vein. But I have little faith in such experiments;—after the ligature of the portal vein, the animal lives but a short period; the blood arrested in its current is conveyed through the medium of inosculations into the general venous circulation, and then, as I have above suggested, if the animal survive sufficiently long, the bile may be secreted from the fluid which contains it, viz. from the arterial blood.

Cuvier entertains the opinion, that the bile is secreted from venous blood, as may be perceived in the following passages:—"Le foie des animaux vertébrés a en effet un caractère qu'il ne partage avec aucune autre glande; c'est que sa sécrétion est alimentée par du sang veineux; par du sang qui a déjà circulé, et qui n'est pas retourné au cœur, ni par conséquent au poumon. Cette circonstance a lieu, non-seulement dans des animaux à circulation double, où tout le sang doit repasser par le poumon, avant de se rendre aux parties, le foie excepté; mais encore dans les animaux à circulation simple (les reptiles), où une si grande portion du sang artériel n'a point retourné au poumon, et tient par conséquent de la nature veineuse; c'est presque alors du sang deux fois veineux qui se rend dans le foie." May we not, therefore, from the powerful arguments afforded by anatomical investigation, and from our knowledge of the compensating energies aroused by nature in cases of anomaly,—may we not, at least until weightier reasons to the contrary shall be

developed by the progressive discoveries of our improving science, conclude that *the bile is secreted from venous blood?*

The *quantity of the bile* is a question difficult to decide accurately; it would appear to be secreted most abundantly during digestion, when the augmented activity of the stomach would seem to be communicated to its neighbouring organ, the liver. Certainly it is evacuated from the gall-bladder into the digestive canal at that period. In animals which have been kept long fasting the gall-bladder is always greatly distended. Schultz observed, in an ox which had been kept for some time without food, from twelve to sixteen ounces of bile in the gall-bladder, and in another, after digestion, from two to four ounces only. In a dog which had not eaten for some time he found five drachms, in another, after digestion, about two drachms. In a case of abscess of the liver communicating with the gall-bladder and lung, recorded by Dr. Monro, the whole of the bile flowed through the fistulous canal and was discharged by coughing, "in proof of which," he says, "the fæces were of the same whitish colour and had as little smell as those of a person deeply jaundiced. The quantity of bile discharged by coughing was different at different times. It was *always greater after meals*, and especially for an hour or two after dinner. The quantity expectorated could not be measured with great accuracy from being mixed with mucus and saliva. The whole quantity in twenty-four hours was from ten to fifteen ounces; and, in this case, I had an opportunity of observing the effects of certain articles of food, and in particular of acids, of wine, and of different fruits, in increasing the quantity of bile."

Expulsion of the bile.—This process I have just shewn takes place more abundantly during digestion than at any other period. In all carnivorous and in most herbivorous animals there exists a peculiar provision for the collection of the bile during the period of abstinence, in a membranous reservoir, the gall-bladder. Some herbivorous animals, deprived of a distinct gall-bladder, have a compensating dilatation upon the hepatic duct. The use of this organ is to retain the bile until digestion demands its excretion. Those animals, therefore, that are provided with it are such as perform the function of digestion at variable intervals. But in those whose digestion is continuous, as is the case in many herbivora, the bile flows as it is secreted into the alimentary canal; being very probably provided more abundantly under the stimulus of a full stomach than during the abstinence from food or during sleep. In the contracted state of the duodenum the small and oblique opening of the ductus communis choledochus is closed to the passage of the fluid; it therefore regurgitates along the cystic duct into the gall-bladder. In the slight ascent along this tube it is facilitated by the spiral valve, which also serves to restrain its too sudden emission during spasmodic action of the abdominal muscles. As soon as the duodenum becomes filled with the chyme from the stomach, the opening of the ductus communis choledochus is less compressed. The distension of the stomach, but more particularly the passage of the chyme along the pylorus into the upper part of the duodenum, causes a gentle pressure upon the coats of the gall-bladder which favours its emission; its contents are gradually expressed, and flowing along the ductus communis choledochus are mingled with the pulpy mass in the duodenum. This explanation of the process seems to have been entertained by Haller, and to have arisen in his mind from the consideration of the anatomy of the serpent, where the gall-bladder is far removed from the liver and is situated in the space formed by the contraction of the pylorus and its termination in the small intestine. Neither do I consider its truth invalidated by those cases in which the gall-bladder is partly imbedded in the liver, for in such instances that portion of the liver is compressed which immediately covers the fundus of the gall-bladder, or a part of the gall-bladder is exposed against which the duodenum may exert an equal compression. Müller conceives that the efferent ducts of glands are surrounded by "an extremely thin layer of muscular substance," which, although not demonstrable anatomically, he thinks to be placed beyond dispute by physiological observations. "The contractile power of the ductus choledochus in birds was known to Rudolphi. By irritating mechanically or by galvanism the ductus choledochus of a bird just dead, I have frequently produced a very strong contraction of it, which continued some minutes, after which the duct resumed its previous state. I have often excited strong local contractions of the ureters likewise, both in birds and rabbits, by the application of a powerful galvanic stimulus. Tiedemann also has seen motions of the vas deferens of a horse ensue on the application of a stimulus. It appears indeed that periodic vermicular motions are performed by the efferent ducts, at least by the ductus choledochus, in birds; for I have once observed in a bird just killed, contractions of the duct occurring regularly in pauses of several minutes, the tube dilating again in the intervals; and what was remarkable, the contractions took place in an ascending direction, namely, from the intestine towards the liver: and this seems to throw some light on the mode in which the bile at certain times, instead of being expelled into the intestines, is retained and driven into the diverticulum of the duct, namely, the gall-bladder; the complete closure of the mouth of the duct contributes perhaps to this effect. The discharge of the bile from the gall-bladder during digestion results probably from the mere pressure of the surrounding parts, and the action of the abdominal muscles, while the mouth of the duct is open: for I doubt if the gall-bladder is contractile; I could produce no contraction of it in mammalia and birds even with the most powerful stimulus of a galvanic battery." Dr. Monro considers the middle coat of the gall-bladder in man to contain muscular fibres; the muscular coat in the gall-ducts of the dog and horse are, he observes, quite distinct, and upon irritation he has seen the gall-bladder contract

in a living animal so as to resemble an hour-glass. Andral thinks that he has perceived muscular fibres in the hypertrophied coats of the gall-bladder, and Ferrus records a case as occurring to Amussat where, in obstruction to the ductus choledochus by a gall-stone, the middle coat of the gall-bladder and ducts above the impediment was evidently muscular. This preparation was seen by Kiernan at the time that it occurred. The bile during its stay in the gall-bladder becomes inspissated by the removal of the fluid part of the secretion, which is most probably taken up by the numerous lymphatics which cover its surface.

The *uses of the bile* are threefold; 1. it acts chemically upon the chyme and produces the separation of the chyle; 2. it combines with the residuum and forms the fæcal matter; 3. it stimulates the mucous surface of the canal and promotes its secretion, and the contractile action of the muscular coat.

Red and yellow substances of Ferrein.—Since the period when anatomists were divided in their considerations of the liver by the two great contending opinions of Malpighi and Ruysch, the former maintaining its composition of glands, and the latter of minute vessels, the majority of observers have adopted the views proposed by Ferrein, who was the first to vindicate the existence of two distinct substances, which he named cortical and medullary. It was reserved for Kiernan in our own day to prove that "the structure of all the lobules is similar;" that "each lobule is the same throughout;" that "one part of a lobule is not more vascular than another;" and that "there is, therefore, no distinction of red and yellow substances in the liver; the red colour results from congestion only." This doctrine being now established as an undisputed truth, it is not surprising to observe that anatomists and pathologists differed in opinion with regard to the relative position and appearance which these two imaginary substances occupied in the respective livers which they chanced to examine, and upon which they established their decision. Thus we find that Ferrein described the medullary substance as being red in colour, and of a pulpy consistence, and the cortical as friable in its structure, and of a yellowish red colour. Autenrieth, on the contrary, found the red substance to be cortical and the yellow medullary. Mappes having obtained a liver in a different state of congestion, conceives that the yellow substance might be named *granulated;* he decribes it as forming convolutions, one while like intestines, and another while branched, flat, or rounded; and the spaces between the convolutions as being rounded, or resembling oblong fissures filled with a brownish and loose substance. Meckel coincides with Mappes in the relative position of these parts; they are not, he says, placed as in the brain, one on the exterior, the other in the interior, but they alternate throughout the entire organ, the yellow substance forming the mass of the liver, and the brown filling the interspaces. Rudolphi objects to the terms medullary and cortical. Bouillaud asserts that the yellow substance presents itself in the form of granulations having the figure, colour, and arrangement of the secreting granules of the bile known, as he remarks, under the name of acini. These granules, he says, are surrounded by the brown substance, which therefore assumes an angular appearance; it is composed of a vascular net-work, and may be compared to erectile tissue. Andral, in his Anatomie Pathologique, says, "Lorsqu'on examine avec quelque soin un certain nombre de foies, l'on y reconnâit l'existence de deux substances: l'une rougeâtre, où se ramifie surtout le systeme capillaire de l'organe; l'autre blanche ou jaunâtre, qui semble surtout destinée à l'accomplissement de la sécrétion biliare. Dans l'état normal ces deux substances sont distinctes." The opinion of Ferrein is opposed by Portal and Cruveilhier: the former anatomist, after reproving certain modern authors who wished to combine the views of Malpighi and Ruysch by admitting that the liver was formed both of glands and of a prodigious number of vessels, contents himself by asserting that Ferrein's idea of the composition of the glands of the liver of two substances was gratuitous. To Cruveilhier the distinction of two substances appears ill founded, for he observes that the two colours when they exist, which is not constantly the case, do not belong to two distinct granulations, but to one and the same, which is yellowish in the centre where the bile predominates, and of a brownish red in the circumference where the blood is situated. Kiernan ranks Müller among the authors who entertain an opposite opinion to that of Ferrein, but I find upon referring to his work upon the glands, that he distinctly admits a kind of double substance although he objects to its designation, medullary and cortical; hence he observes:—"Diversam substantiam hepatis, utpote medullarem et corticalem, quæ per hepar totum undique obveniunt, qualem Autenrieth, Bichat, Cloquet, Mappes, atque etiam J. Fr. Meckel admittunt, equidem neque in historia evolutionis amphibiorum et avium, neque in hepate adultorum microscopice observato conspexi. Historia evolutionis hanc quæstionem evidentissime illustrat. Systema nimirum ductuum biliferorum in embryone amphibiorum et avium liberis finibus in superficie hepatis prominulis conspicuum. Sarmentula illa foliatim et paniculatim divaricata, colore e gilvo candido nitent, magnopere ab interstitiis sanguinolentis distincta. Hinc sane duplicis substantiæ species exoritur, quoniam circum ductuum biliferorum a tela conjunctiva expleantur, quæ ex subtilissimis fere constat vasculorum sanguiferorum retibus, in quibus arteriæ et venulæ advehentes in revehentes venas transeunt. Atque hæc sola est utriusque substantiæ notio. Sed in omnibus organis glandulosis fere idem obvenit." In his Physiology he is disposed to modify his previous idea of two substances, for he says, "From my researches, however, it results that there is but one kind of *real* hepatic substance, formed of agglomerated biliary canals; but the ramified divisions of this sub-

tance being connected by a *vascular cellular tissue*, which is often of a dark colour, a contrast between this and the yellow substance of the acini is produced. A similar relation of the constituent parts of the liver exists in the embryo of the bird; in it the yellowish twig-like ramifications of the biliary canals are seen on the surface of the organ rising out of a reddish vascular tissue."

M. Dujardin, in an article entitled, "Recherches Anatomiques et Microscopiques sur le Foie des Mammiferes,"* has advanced some opinions which he conceives will throw a doubt over the labours of Kiernan. My space will not permit an analysis of his paper, but it will be obvious to all who may be disposed to read it, that he has not advanced a single new fact, but on the contrary has confessed the most imperfect and inadequate means of examination. Thus, he observes, "with an injection sufficiently fine we can inject the portal vein as far as the capillaries which surround the lobules." Therefore, according to him, the interlobular veins are capillaries, and we need not wonder that with such injection he gets no further, but denies the existence of vessels in the lobules altogether. The lobules, he says, are composed of glutinous corpuscules or globules, which leave channels between them, through which the corpuscules of the blood pass without alteration; at the same time by an action analogous to the phenomena of absorption and assimilation in the lower animals, these lobules separate from the serum the excrementitious particles which are excreted upon the surface of the lobule. The blood of the portal vein is transmitted through the lobule by a kind of "*filtration organique*," and from it the resinous matters of the bile are eliminated; the arteries, on the contrary, secrete the alkaline substances, which in the first instance dissolve the resinous substance, and afterwards constitute the true agents of digestion. M. Dujardin concludes his theoretical but ingenious speculations with an excuse for being obliged to give them to the world in their present imperfect state, and promises to renew his researches with perseverance. I feel pleasure in recording his promise, and have no doubt that by better directed injections in the human liver, using size and vermilion in place of oils and varnish, he will be induced to modify his views with regard to this most interesting organ.

Pathological anatomy of the liver.—If we consult the works of pathological writers upon this subject, we shall observe at every step of our progress the greatest ambiguity and difference of opinion to exist. The reasons for this want of consent upon the true nature of the diseases of so important an organ are not to be ascribed either to want of talented observers or of excellent observations, but solely to the ignorance which has hitherto prevailed with regard to the exact anatomy of the organ. I have shewn that the most celebrated authors found it necessary in starting with their inquiries to establish for their guidance a theory of the structure of the liver; this theory was based upon imagination or upon deceptive appearances; and upon this frail basis the crumbling superstructure of their pathological deductions is supported. The hypertrophy or atrophy of the white or of the red substance, and the wild speculations of pathological theorists, have now fallen into the shade before the light which recent discoveries have thrown upon the anatomy of the liver. Intimately associated with that anatomy, and with the knowledge of the distribution of the vessels, is the explanation of the mode in which the circulation is performed, and the elucidation of the causes which may give rise to impediment in its course; in other words, the principles of congestion. Indeed, so closely allied is that condition with the natural circulation, that Kiernan, in his paper upon the Anatomy and Physiology of the Liver, has deemed it a part of the subject to explain the various congestions to which the organ is liable, and the manner in which they may be imitated artificially. Upon this point we have, therefore, precise information, and the history of congestion we may regard with a feeling of satisfaction. The same observations, with the exact anatomy of the liver as a basis, have not as yet been extended to its diseases; our knowledge of these is therefore necessarily imperfect. Kiernan concludes his paper with a paragraph of much importance to this branch of pathology:—"While engaged in the examination of the natural structure of the liver, I have not been inattentive to the changes produced in it by disease; and, with the permission of the Society, I propose submitting to its consideration a paper on the morbid anatomy of this organ." Now this was written in 1838, and I trust that the time is not far distant when the additional labours of that excellent observer will be placed in the hands of the profession.

In the arrangement of the diseases of the liver I have adopted a physiological order, and shall consider its morbid conditions under the seven following heads:—

1. Diseases of the serous membrane.
2. Diseases of the mucous membrane.
3. Disorders of the venous circulation.
4. Disorders of biliary excretion.
5. Diseases of the parenchyma.
6. Disorders of function.
7. Entozoa.

1. *Diseases of the serous membrane.*—The serous covering of the liver, like serous membranes in other parts of the body, is liable to *acute inflammation*. The effects of this inflammation are also similar; the capillary vessels become over-distended and lose their power of contraction; coagulable lymph is effused upon the surface of the organ, and causes its mechanical cohesion to the contiguous serous membrane; the coagulable lymph becomes organised by the development of new capillary vessels from the meshes of the old, and the adhesions are traversed by vessels of larger size, and constitute a permanent bond of

* Annales Françaises et Etrangères d'Anatomie et Physiologie, 1838.

union between the peritoneum proprium and the peritoneum reflexum. In this state, adhesions are not uncommonly met with upon the convex surface of the liver, but not so frequently upon its concave side. The inflammatory action is confined to the peritoneum of the organ itself, and that of the parietes of the abdomen immediately in contact with it, and seldom extends to the serous membrane of neighbouring viscera. This is the *membranous hepatitis* of pathological writers, and is accompanied by considerable local uneasiness, and by sympathetic pains in various parts of the body, dependent upon the communication of its proper nerves with the nerves of other regions, as with the phrenic nerve, giving rise to pain in the right shoulder and chest, with cough; with the pneumogastric nerve, producing uneasiness at the cardia, pain along the œsophagus, dysphagia and nausea; and with the solar plexus and lesser splanchnic nerve, causing pain in the right kidney, &c. This disease is usually associated with chronic congestion of the substance of the liver, but exists, sometimes, quite independently of any internal morbid action.

As a consequence of *chronic inflammation*, the serous membrane is sometimes thickened and opaque and dense in its consistence; at other times it is less resisting than natural and easily broken.

Depositions are occasionally found in the subserous tissue of the liver as a result of chronic inflammation of the serous membrane. They consist most frequently of an atheromatous substance, and occasionally of thin plates, having a cartilaginous density and appearance. The gall-bladder is not unfrequently thickened in its coats by the deposition of fat, of tuberculous, or of calcareous substance. The latter has been described as ossified gall-bladder.

2. *Diseases of the mucous membrane.*—Inflammation of the mucous membrane of the liver is acute or chronic, and is more frequent than that occurring in the serous membrane. Being continuous with the mucous membrane of the duodenum, the lining of the biliary ducts and gall-bladder is constantly subject to sources of irritation from disorders of digestion, improper aliment, and stimulating substances taken into the alimentary canal, or from any cause giving rise to undue action in the intestinal mucous surface. Almost all the chronic diseases of the liver are to be referred to this prolific source, and it is also by means of this direct continuity that many of the therapeutic remedies exert their alterative influence. The effects of inflammation on the mucous membrane, are

a. Thickening.
b. Softening.
c. Hæmorrhage.
d. Suppuration.
e. Deposition.

a. Thickening of the submucous tissue is the most frequent consequence of irritation of the mucous membrane; the calibre of the ducts is in this way diminished; actual stricture and obliteration of the tubes occurs, and the bile, at first but partially impeded, becomes altogether obstructed. The gall-bladder is sometimes enormously thickened, particularly where the irritation is kept up by the presence of several or a single large gall-stone. The coats are usually very much condensed and contracted, and their structure appears lost; occasionally they are dilated. In a case which occurred to Amussat,* wherein the ductus communis choledochus was obliterated, and the gall-bladder and ducts were very much distended, the middle coat presented all the characters of muscular fibres.

b. Softening of the mucous membrane may occur in the biliary ducts, but more particularly in the gall-bladder, and from the same causes which produce it in other mucous surfaces. I have seen two instances in the gall-bladder in which patches of the surface were converted into a softened pulp, which gave way upon the distension of the sac with air.

c. Hæmorrhage.—The gall-bladder has been observed filled with blood, having its source in the capillaries of the mucous membrane. In these cases intestinal hæmorrhage had occurred before death, and upon examination, no congestion or lesion could be found in the mucous membrane other than that which was seen in the gall-bladder.

d. Pus has likewise been found in the gall-bladder, and in the larger hepatic ducts, sometime pure, but generally mingled with the bile.

e. Abnormal *deposits* in the submucous cellular tissue are occasionally seen. They are most frequent in the gall-bladder, and consist generally of calcareous accretions.

3. *Disorders of the venous circulation.*—Under this head I have to describe the various forms of congestion of the liver. It has been customary hitherto to consider hepatic congestion as a pathological condition, and in compliance with that custom I have given it a place under the above title, although I shall have occasion to shew that it is not in itself a disease, but the mere result of diseased actions occurring in other parts, and wholly dependent upon the peculiar anatomical structure of the organ. Andral, in his excellent work on pathological anatomy, observes, " L'hyperémie du foie est un des états morbides que présente le plus fréquemment cet organe. Tantôt cette hyperémie est générale, alors le foie est partout d'un rouge uniforme; son volume est augmenté et sa consistance peu changée, lorsque l'hyperémie est simple. Cette hyperémie est souvent partielle; alors, en un certain nombre de points, on trouve comme des taches rouges variables en forme et en grandeur, qu'entoure un parenchyme plus pâle.

" Trois espèces d'hyperémie du foie doivent être admises, relativement aux conditions de l'économie dans lesquelles elles surviennent.

" Une première espèce d'hyperémie est celle

* Dictionnaire de Médecine, article Foie. Mr. Kiernan was the pupil of Amussat at this period, and saw this interesting case. He informs me that the appearance was distinctly muscular.

qui résulte d'un travail d'irritation dont le foie est devenu le siége. Cette irritation est tantôt idiopathique, et tantôt elle est la suite d'une irritation primitivement fixée sur le tube digestif.

" Une seconde espèce d'hyperémie, dont le foie me paraît susceptible, est celle dans laquelle le sang s'accumule d'une manière toute passive au sein du parenchyme hépatique, comme il s'accumule dans les gencives des scorbutiques.

" Enfin le troisième espèce d'hyperémie du foie est purement mécanique; elle s'observe dans les cas où un obstacle quelconque s'oppose à la libre entrée du sang dans les cavités droites du cœur; le sang stagne alors dans les veines sus-hépatiques, et *engorge* le foie."

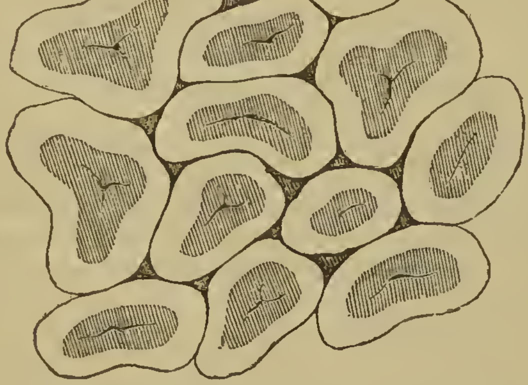
Now the researches of Kiernan have proved that " in consequence of its double circulation, the liver is naturally in a state of sanguineous congestion" after death, and that author has also pointed out the various forms of congestion which are observed in the organ. " Sanguineous congestion of the liver," he observes, " is either general or partial."

a. General congestion affects the whole of the substance of the liver, which presents a generally diffused red colour; the central portions of the lobules having usually a deeper hue than the marginal portions.

Partial congestion is of two kinds,
Hepatic venous congestion.
Portal venous congestion.

b. Hepatic venous congestion may exist in two stages. " In the first and most common stage (*fig.* 42) the hepatic veins, their intralobular branches, and the central portions of the lobular venous plexuses are congested. The congested substance is in small isolated patches of a red colour, and occupying the centres of the lobules is medullary; the non-congested substance is of a yellowish white, yellow, or greenish colour, according to the quantity and quality of the bile it contains; it is continuous throughout the liver, and forming the marginal portions of the lobules is cortical."

Fig. 42.

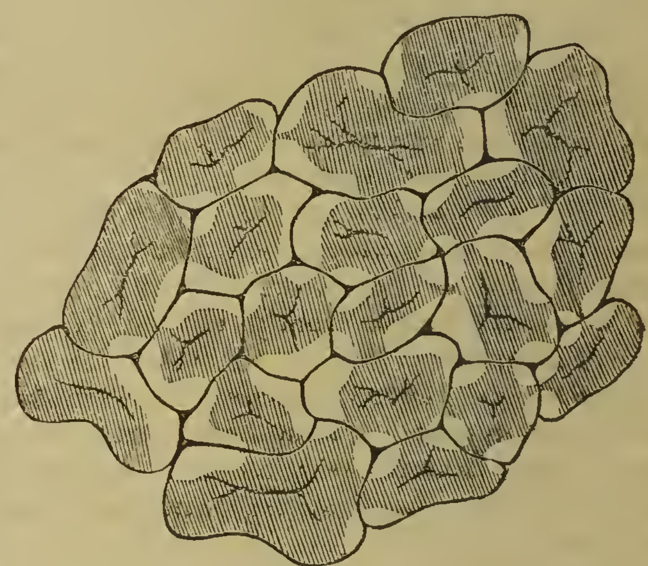


Rounded lobules in the first stage of hepatic venous congestion, as seen upon the surface of the liver. After Kiernan.

"This is the usual and natural state of the organ after death," and arises from arrest in the circulation of the hepatic veins, while the current of blood in the minute branches of the portal vein is still in motion.

" In the second stage (*fig.* 43) the congestion extends through the lobular venous plexuses to those branches of the portal vein situated in the interlobular fissures, but not to those in the spaces, which being larger there and giving origin to those in the fissures, are the last to be congested; when these vessels contain blood the congestion is general, and the whole liver is red. In this second stage the non-congested substance appears in isolated circular and ramous patches, in the centres of which the spaces

Fig. 43.

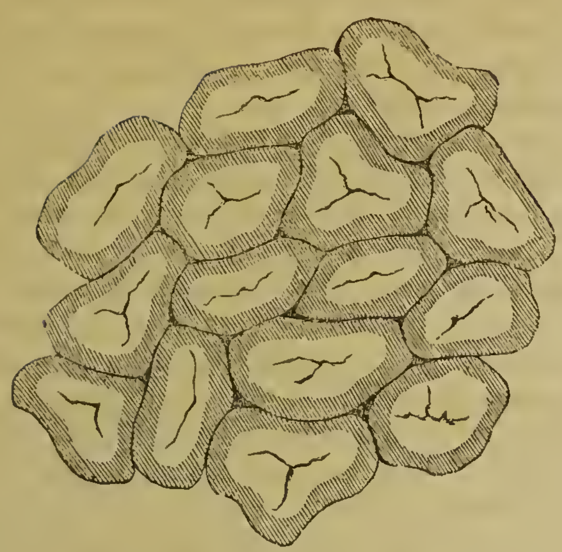


Lobules in the second stage of hepatic venous congestion, as seen on the surface of the liver. The dark centres of the preceding stage have become conjoined at the interlobular fissures, while the uncongested parts encircle an intralobular space.

and fissures are seen. This form of congestion " very commonly attends disease of the heart and acute disease of the lungs or pleuræ; the liver is larger than usual in consequence of the quantity of blood it contains, and is frequently at the same time in a state of biliary congestion, which probably arises from the sanguineous congestion. Although in the first stage the central portions of the plexuses, and in the second the greater portion of each plexus, and those branches of the portal vein occupying the fissures are congested, and although the plexuses are formed by the portal vein, yet as this form of congestion commences in the hepatic veins and extends towards the portal vein, and as it is necessary to distinguish this form from that commencing in the portal vein, the term of hepatic-venous congestion will not probably be deemed inapplicable to it." The second stage of hepatic venous congestion, generally combined with biliary congestion, gives rise to those various appearances which are called dram-drinkers' or nutmeg liver.

c. " Portal venous congestion is of very rare occurrence; I have seen it in children only. In this form, the congested substance never assumes the deep red colour which characterises hepatic-venous congestion; the interlobular fissures and spaces and the marginal portions of the lobules are of a deeper colour than usual; the congested substance is continuous and cortical, the non-congested substance being me-

Fig. 44.



Lobules in a state of portal venous congestion, as seen on the surface of the liver. The congested part occupies the margins of the lobules, the uncongested portion their centres. After Kiernan.

dullary and occupying the centres of the lobules."

The causes of congestion are all such as tend to interfere with the circulation in the liver or with the general circulation; for instance, impediment to the circulation of the blood through the capillaries of the lungs, diseases of the valves of the heart, aneurism, &c. A slighter degree of obstacle produces congestion of the hepatic veins only, the venous turgescence being limited by the lobular venous plexus. If the obstruction be greater, the lobular venous plexus itself is congested; if the cause continue, the congestion extends through the interlobular fissures into the neighbouring lobules, and in a more advanced degree the congestion spreads itself throughout the whole of the lobules, and becomes general. From the liver the congestion extends to the alimentary canal, and gives rise to intestinal hæmorrhages, hæmorrhoids, ascites, &c.

The variety of appearance in the vascularity of the lobules in congestion, and the constancy of its occurrence, have deceived those pathologists who maintain the existence of two substances, and the difference of position and form of the congested and uncongested portions has given cause for the diversity of opinion with regard to its situation. For a perfect elucidation of these difficulties, physiology is indebted to the genius and perseverance of Kiernan. The mode in which the attention of this author was drawn to the subject forms part of the history of hepatic congestion, and deserves to be detailed in his own words. "My attention," he observes, "was first directed to the anatomy of the liver by the study of the admirable works of M. Andral. In the first organs I examined I found the small branches of the hepatic veins ramifying exclusively in the red, and those of the portal vein in the yellow substance. I concluded that the liver was composed of two venous trees, a portal and an hepatic tree, the former having a cortex of yellow, the latter of red substance; and with M. Bouillaud, I thought it probable that the red substance was the organ of the function imagined by Bichat. I next ascertained the lobular structure, and concluded with Ferrein, that the red substance was medullary and the yellow cortical. Subsequent dissections, in which I found branches of both the portal and hepatic veins ramifying in the red substance, tended to unsettle the opinions I had formed respecting the anatomy and physiology of the two substances, and these opinions were finally overturned by the examination of a liver in which I found the branches of the portal vein alone ramifying in the red, and those of the hepatic veins in the yellow substance. The only conclusion that could be drawn was, that the red colour resulted from congestion; that it was medullary, occupying the centre of each lobule, when the hepatic, and cortical forming the circumference, when the portal vein was congested."

Müller, in the eleventh figure of plate 11 of his admirable work on the glands, has made a singular error with regard to the structure of the liver, and the arrangement of the ultimate biliary ducts. In the description of this figure he says, "Segmentum hepatis Sciuri junioris, microscopio simplici visum. Observantur fines ductuum biliferorum elongati, seu cylindri-

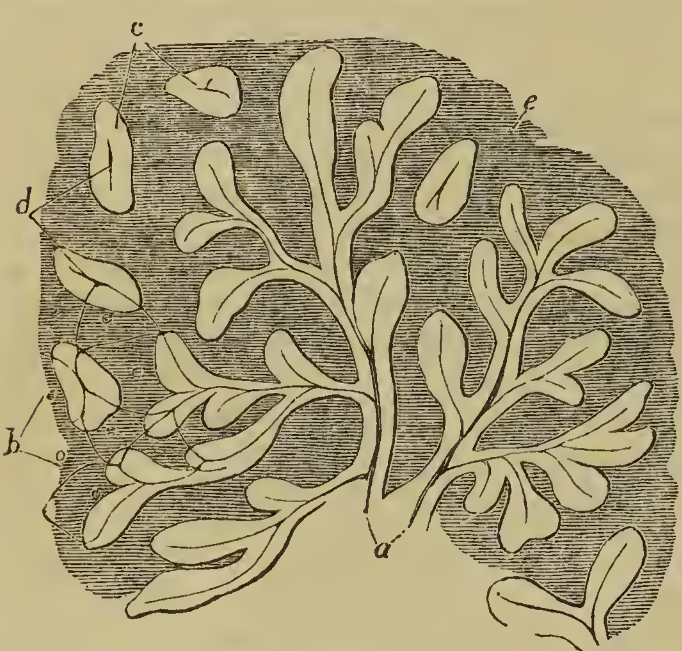
Fig. 45.

A part of Müller's 11th figure of plate 11, which he considers to represent the distribution and arrangement of the ultimate biliary ducts. The liver in this section is in a state of hepatic venous congestion in the second stage. The congested portion corresponds generally with the central or hepatic part of the lobules, and the uncongested portion with the interlobular fissures, in which are situated the branches of the portal vein.

a, A small branch of the portal vein giving off twigs to the various interlobular spaces. If these twigs be continued so as to unite with each other, the form of the lobules will be apparent; as at *b*, *b*. The angles formed by the giving off of the twigs from the portal vein are the interlobular spaces. *c*, Irregularly oval patches of uncongested lobules; the dark spot in the centre is an interlobular space, from which the portal vein radiates in various directions, so as to surround the various lobules by whose conjunction the space is formed. *d*, *d*, Lobules entirely congested. In the centre of the lobules of this section I have marked the situation of the intralobular vein, although it may not be apparent, or but slightly so, in the congested liver. The small spaces, *e*, *e*, generally mistaken for intralobular veins in this form of congested liver, are interlobular spaces.

formes acini, in figuris ramosis et foliatis varié dispositis." Now the truth is, that this section is in the second stage of hepatic venous congestion, and the "figuris ramosis et foliatis" are simply the uncongested portions of the lobules, of a lighter colour than the rest, and presenting the foliated and ramous appearance which is common to this form of congestion. The "fines ductuum biliferorum elongati seu cylindriformes acini" are obviously imaginary. The dark lines in the centre of the foliated ramifications are small branches of the portal vein lodged in interlobular fissures. If the twigs given off by these branches be made to unite with each other, we shall then have the true form of the lobules. This has been done in *fig.* 45, upon a part of Müller's drawing, for the purpose of shewing how the error has arisen, and how the form of the lobules may be restored. This appearance of the congested liver is by no means unfrequent in occurrence, and I subjoin a careful and accurate drawing of a similar arrangement in the human liver, (*fig.* 46,) for the purpose of comparison with that of Müller.

Fig. 46.



Section of a portion of liver exhibiting hepatic venous congestion in the second stage, carefully delineated from nature by Bagg, and intended to be compared with Müller's figure.

a, The portal vein in an interlobular fissure, giving off small twigs to adjoining fissures, and surrounded by the uncongested portion of the liver. *b,* The form of a few of the lobules is shewn. *c,* Irregular patches of uncongested liver, as in Müller's figure; the space in the centre of each being an interlobular space. *d,* Interlobular spaces. *e,* The congested portion of the liver.

Coming from so high an authority as Müller, this figure has been copied without hesitation by several writers, together with the explanation given of it by the author. Mr. Grainger has introduced it into his article upon the glands in this Cyclopædia, *fig.* 217, page 485, and Mr. Carpenter has also given it a place in his recent excellent work* on physiology. In his text, the latter gentleman observes with regard to the figure:—"In the squirrel indeed these pro longations may be distinctly seen, the blind sacs being cylindrical in form, and closely packed together."

Hepatic venous congestion in its most common form, viz., in the second stage, is the great stumbling-block of all anatomists who have engaged in the investigation of the minute anatomy of the liver; and it is under this head that I must now consider the views of Cruveilhier with regard to the supposed normal anatomy of this organ. Isolated from the distribution of the vessels in the liver, he has described the form and arrangement of the lobules with sufficient accuracy; but then it must be remembered that his description was written subsequently to the publication of the researches of Kiernan. But his conception of the structure of the lobules is completely erroneous, for after combating the common error of the existence of two distinct substances, he says:—"Les deux couleurs jaune et brune quand elles existent, n'appartient pas à deux granulations distinctes, mais bien à la même granulation qui est jaune au centre, où se trouve le bile, et rouge-brun à la circonférence, où se trouve le sang." Now Kiernan has distinctly proved that the structure of the lobules is the same throughout, and their colour is also uniform. Cruveilhier must therefore have founded his opinion and his description upon a liver in the second stage of hepatic congestion, in which there exists a delusive indication of lobules having the appearance of small oval and variously shaped patches, of a yellowish colour, situated at regular intervals, and surrounded by a reddish brown substance. These yellowish spots are seen in *figs.* 43, 45 & 46. They are the clusters of terminal biliary ducts of Müller,—the central portions of the lobules of the liver of Cruveilhier; but if they be examined carefully, their true nature will become clearly apparent. They are actually the *uncongested portions of the lobules of a liver in the state of hepatic venous congestion* at the second stage, and have each an interlobular space for a centre. In the next passage Cruveilhier observes:—"Le foie humain, excepte dans les cas de *dévelopment considérable* des granulations, se prete difficilement à leur etude vu leur petitesse." Here again in the words "dévelopment considérable," we perceive an idea founded upon the same erroneous impression with regard to the structure of the lobules. The real lobules are as nearly as possible of the same size in the liver of every individual, but these imaginary lobules of Cruveilhier, having uncongested portions of the hepatic substance for centres, necessarily vary in size and form with the degree of congestion, and hence have given rise to the idea of an increased development of the lobules. Again, the true lobules are not so small in the human liver as to render their examination difficult; they may be seen distinctly with the naked eye, and with the commonest lens may be examined accurately. But in the congested

* Principles of General and Comparative Physiology, 1839.

state of the organ they are more obscure, as may easily be inferred when we perceive such distinguished authorities as Müller and Cruveilhier, from want of making the liver the subject of especial investigation, deceived by such appearances. That Cruveilhier has actually mistaken the uncongested patches seen on the surface of a congested liver for the lobules, is clearly proved by a succeeding paragraph :—"Du reste, le volume des grains glanduleux présente beaucoup de variétés suivant les individus, et ce volume est tout-à-fait indépendant du volume du foie lui-même. Les médecins qui s'occupent d'anatomie pathologique ont souvent noté ce dévelopment, sous le titre d'hepar acinosum. Il est une maladie caractérisée par la coincidence de l'atrophie du foie, qui est réduit à la moietié, au tiers de son volume, et du dévelopment considérable des grains glanduleux." Now the hepar acinosum is without question a liver in the second stage of hepatic venous congestion, and presents several varieties in the precise form of the uncongested patches.

Starting with erroneous data such as these, what can be expected as the result of an experimental injection of the liver made by Cruveilhier, those who are thoroughly informed upon the exact anatomy of this organ will have no difficulty in anticipating; but to those who are only imperfectly acquainted with it, his conclusions must appear startling :—"Le foie ainsi injecté soumis à divers agens chimiques a présenté les resultats suivans: 1, l'injection bleue, c'est-à-dire celle de la veine cave, avait pénétré dans la partie centrale des grains glanduleux, partie qu'on appelle substance jaune du foie. Au milieu de la partie centrale était l'injection jaune, c'est-à-dire l'injection du canal biliare. Autour de l'injection bleue, etait l'injection rouge, c'est-à-dire, l'injection de la veine porte, et de l'artère hépatique, qui occupait toute la substance dite rouge du foie. Il suit de là que chaque grain glanduleux présente un appareil vasculaire ainsi disposé: 1, au centre, un canal biliare; 2, sur un plan plus excentrique, un cercle vasculaire formé par les ramifications de la veine hepatique; 3, un cercle vasculaire concentrique au précédent, formé par les ramifications de la veine porte et de l'artere hepatique." Thus in the centre of *his* lobule, Cruveilhier* found the yellow colour of the ducts, most probably effused and colouring the whole of the yellow portion of his lobule. Next came a circle of blue, and then a circle of red, formed conjointly by the portal vein and hepatic artery. Now we have shewn that the centre of Cruveilhier's lobule is an uncongested patch formed by the contiguous margins of several adjoining hepatic lobules, and having an interlobular space for a centre;—where, therefore, could we expect to find the yellow but in the interlobular space, and diffused immediately around it, so that the colouring matter would obscure the red injection of the portal vein and artery of that immediate point. Around the uncongested patch and in the congested substance we should find the intralobular veins of three or four or five surrounding hepatic lobules, (hence the variable size of Cruveilhier's lobules,) embracing by a kind of zone the yellow centre; and externally to the vein, the surrounding interlobular fissures would display the red injection of the portal vein and hepatic artery.

4. *Disorders of biliary excretion.*—Biliary congestion may be produced by various causes; the most frequent is temporary thickening of the mucous lining of the ducts from inflammation or capillary congestion; this will simply diminish the calibre of the ducts or produce a complete stricture. The obstruction may endure for a shorter or longer period; the swelling of the membrane may subside and the tube be restored to its original dimensions, or it may become chronic and be a permanent impediment to the free current of the bile. Another cause of congestion of the bile-ducts is hepatic venous congestion, which acts by producing pressure upon the lobular biliary plexus and interlobular ducts. This is usually a chronic cause. Congestion of the bile-ducts may likewise depend upon the impaction of a gall-stone in the larger biliary ducts or ductus choledochus, obliteration of one of the ducts by the pressure of a tumour, disease of the pancreas, or thickening of the mucous membrane of the duodenum. In each of these cases the ducts are loaded with bile, which gives a yellowish or greenish hue to the whole substance of the liver. Biliary congestion in a chronic form is usually accompanied with more or less of hepatic venous congestion.

When one of the bile-ducts is obliterated or obstructed by a biliary concretion, the ducts become dilated above the constriction, and considerable reservoirs are formed in the substance of the organ. If the impediment exist in the ductus choledochus, the gall-bladder becomes greatly distended as well as the biliary ducts. The irritation caused by the pressure of the bile has given rise to inflammation and ulceration of the coats of the gall-bladder or of the ducts, and the bile has been effused into the peritoneal cavity and produced death. When the cause of the obstruction is a biliary calculus of moderate size, the pressure of the column of the bile will sometimes force it onwards into the duodenum, and thus remove the impediment. In other cases, when the obstruction occurs in the cystic duct, the bile ceases to enter the gall-bladder, the sac becomes thickened and diminished in size, and filled with a colourless viscid mucus.

5. *Diseases of the parenchyma.* — The diseases of the substance or parenchyma of the liver may be referred to the following heads:—*a*, inflammation; *b*, hypertrophy; *c*, atrophy; *d*, softening; *e*, induration; *f*, fatty degene-

* These injections were not made by Cruveilhier himself, but by his assistant M. Bonami, as we are informed by M. Dujardin, in his paper "sur le foie, &c." The material used for the purpose was spirit varnish, and the results were not always successful.

ration; *g*, pus; *h*, tubercle; *i*, scirrhus; *k*, medullary sarcoma; *l*, fungus hæmatodes; *m*, melanosis.

a. Inflammation.—The tissue of the liver is liable to inflammation,—hepatitis, or the lobular hepatitis of some writers. The symptoms, like those detailed in the consideration of inflammation of the serous membrane, are severe and prominent, and clearly indicative of the nature of the disease. The pathologic appearances are deep redness, softness, general congestion, and enlargement of the organ from distension with blood. This condition is but rarely observed, from the circumstance of inflammation of the liver having no direct tendency to cause death, but being rather the precursor of the various other forms of disease which affect the organ. All the changes which occur in the liver are preceded or accompanied by inflammation acute or chronic, but more frequently by the latter, and in most instances by derangement of the venous circulation, and, occasionally, of the biliary excretion, giving rise to a complication of venous and biliary congestion.

b. Hypertrophy of the liver is increase of bulk of the organ, not depending, as in congestion, upon the quantity of blood circulating through it, but upon actual augmentation of the tissues of which it is composed. This state of enlargement of the liver may be general, or it may be confined to a part, as to a single lobe. Its predisposing cause is probably irritation of the mucous membrane of the ducts which gives rise in the first instance to retarded circulation and venous congestion, or it may be impediment either in the circulation through the heart, or through the rest of the venous system; or, again, it may depend upon diminution of the general powers of the system, as in a scrofulous constitution. The lobules are always in a state of partial congestion, resembling the second stage of hepatic venous congestion; the congested portion presents a deep red tint, and the uncongested part is ramose or convoluted in appearance, of a dirty white, greyish, yellowish, or greenish hue, in proportion to the condition of the biliary apparatus and to the quantity of bile contained within the liver. Sometimes the organ is pale, and appears deficient in its supply of blood; at other times it has a generally diffused redness, or the congestion may be greater in some situations than in others. The consistence of the liver in hypertrophy is equally variable with its colour: sometimes it is softer than natural, at other times it is dense and apparently granulated, the uncongested part projecting from the surface, and the congested portion sinking beneath its level. Hypertrophy of the liver is generally associated with chronic disease of the lungs, scrofula, and rickets, and often exists as a cause in ascites. It has been observed fifteen, eighteen, thirty-five, and even forty pounds in weight, and to have produced the displacement of the other abdominal viscera by its enormous size.

c. Atrophy of the liver is a condition of the nutritive functions of the organ which may succeed chronic inflammation or even hypertrophy; it occurs more rarely than hypertrophy, to which its comparative frequency has been estimated by Portal as 5 to 95. The substance of the liver diminishes in bulk, the lobules become indistinct and variously congested, and they appear intermingled and pressed upon by the cellular structure with which they are surrounded. Sometimes the proper structure of the liver is entirely removed and replaced by a loose or condensed cellular tissue. At other times the entire substance of the organ appears to have been absorbed by an enormous abscess, which has evacuated its contents into the intestinal canal, and the parietes have afterwards contracted and degenerated into an atrophied mass. Lieutaud gives an account of a liver that was shrivelled into a mass not larger than his fist. Portal found the liver in a case of ascites not bigger than an apple of ordinary size. Partial atrophy of the liver conjoined with hepatic venous congestion is not an infrequent consequence of the practice of tight lacing. I have before me a very interesting specimen of this affection. The surface of the liver is marked by deep fissures into irregular polygonal divisions resembling very strikingly the lobulated appearance of the fœtal kidney. In one situation the stages of this change are distinctly apparent; a certain portion of the organ, about half an inch in breadth, has become partially atrophied from the pressure of two adjoining and protuberant portions of the liver, and in the lobulated portion the hepatic substance of this atrophied mass has been completely removed by absorption, leaving a kind of condensed cellular cicatrix extending like a septum for some distance into the organ. It is in this way that many of the grooves and fissures upon the convex surface of the liver are formed.

But the most interesting form of atrophy of the liver is that which was named by Laennec cirrhosis. In cirrhosis, the liver is diminished in volume to the extent of one-half or one-third of its natural bulk, the relative size of the right and left lobes is destroyed, and the surface is rendered shapeless by the projection of a number of ridges or granular points. The entire organ appears wrinkled and shrivelled, and of a yellow or greenish colour, varying in tint from a bright chrome to a yellowish or greenish brown. Upon dividing it with a knife it is observed to be more dense than usual, and the surface of the section presents a number of patches of variable size and of a roundish form, which resemble granules; hence this condition of the organ is named by the French authors "foie granuleux." In an advanced stage it is accompanied with jaundice and ascites, and is frequently preceded by some disease, either of the lungs or heart.

Kiernan is, I believe, the first pathologist who distinguished the true nature of cirrhosis, which he called *atrophy of the liver*. A very interesting case of this disease occurred in St. Bartholomew's Hospital, under the care of Dr. Latham, in 1832, an account of which was published in the *Lancet* in November of that

year. The patient died with jaundice and ascites. The liver, a portion of which I possess, presented a fine specimen of granulated cirrhosis; it "was diminished to one-half its natural size, and Mr. Kiernan on injecting it, discovered that a *collateral venous circulation had been established by way of the diaphragm.*" In another case in a woman who had been tapped ninety times, Kiernan upon injecting the liver found that the same kind of collateral circulation had been formed. The circulation through the liver had been impeded by the developement of condensed cellular tissue, and the greater part of the blood of the portal vein had made its way through dilated vessels upon the surface of the organ to the diaphragm, and from thence into the general venous circulation. In this case there were numerous bands of adhesion between the liver and diaphragm, and between the intestines and the walls of the abdomen, and these also were traversed by large veins conveying blood from the portal vein into the general venous current.

With regard to the pathological nature of the disease many opinions have been entertained by different writers. Laennec, dazzled by an ingenious theory deduced from his observations upon the nature and progress of scrofulous tubercle, saw in the mottled and granular section of cirrhosis only a "morbid deposit," a special accidental tissue existing in the two states of crudity and softening. But I quote the words of this author as detailed by Ferrus,* for while he errs in his speculations with regard to the nature of the disease, he draws an excellent picture of its general characters and appearance. "Les cirrhons existent dans l'état de crudité et de ramollissement. Dans le premier de ces états elles présentent un tissu d'une couleur fauve plus au moins foncée, qui quelquefois tire un peu sur le verdâtre; on ne peut s'en faire une meilleure idée qu'en la comparant à celle qu'offrent les capsules surrénales chez l'adulte. Ce tissu, quoiquefort consistant, a une sorte de flaccidité que je ne puis mieux comparer qu' à celle de certains fongus, ou d'un cuir mou. Le tissu des cyrrhoses est d'ailleurs compact, assez humide et très-délié. On n'y distingue aucune trace de fibres, quoiqu'il presente en certains cas des divisions en forme de squames. Les cyrrhoses prennent en se ramollissant une couleur plus brunâtre."

"M. Laennec admet trois sortes de cyrrhoses: 1°. cyrrhoses en masses; 2°. en plaques; 3°. en kystes. Lorsqu'il existe, dit-il, des cyrrhoses dans le foie, elles forment ordinairement de petites masses dont le volume ne surpasse jamais celui d'un noyau de cerise, et quelquefois égale à peine celui d'un gros grain de millet. Ces masses sont toujours extrêmement nombreuses, et tout le tissu du foie en est parsemé. Leur petitesse fait que lorsqu'on incise un foie dans lequel il en existe un grand nombre, son tissu paraît au premier coup d'œil homogène et d'une couleur jaune fauve. Mais si on examine plus attentivement le tissu hepatique, on s'aperçoit facilement qu'il est rempli d'une innombrable quantité de corpuscules assez semblables, pour l'aspect à ces lobules de graisse durcie et rousseâtre que l'on trouve communément dans le tissu cellulaire souscutané de la cuisse et de la jambe des sujets attaqués d'anasarque. Ces petites masses sont quelquefois unies très-intimement au tissu du foie; mais assex souvent elles en sont separées par une couche mince de tissu cellulaire qui leur forme une enveloppe tenue, et alors ils se détachent assez facilement. La surface extérieure du foie devient flétrie, rugueuse, et ratatinée à-peu-pres de la même manière qu'une pomme flétrie."

* Dictionnaire de Médecine, Art. Foie.

Bouillaud* considers this condition of the liver a dissociation of the two natural elements of the organ: "les masses jaunes fauves constituant le tissu accidentel, appelé cirrhose, ne sont autres chose que les granulations secretoires se desorganisant graduellement par l'effet de l'obliteration du lacis vasculaire, et de l'obstacle à la circulation hepatique qui en resulte." We have already combatted the existence of two substances, and further remark upon this subject must be quite unnecessary.

Andral † sees, in the cirrhosis, atrophy of the red substance and hypertrophy of the yellow substance. Of all modern authors, Cruveilhier approaches nearest to the true condition of the organ, but from his misapprehension of the exact nature of the lobules, even his opinion cannot be accepted without limitation. Cirrhosis, says this author,‡ is "atrophie du plus grand nombre des grains glanduleux, et hypertrophie avec coloration jaune des grains glanduleux restans." Now cirrhosis is undoubtedly a partial atrophy of the liver with hypertrophy of the cellular structure; complete atrophy of some of the lobules, partial atrophy of others, and biliary congestion without atrophy or hypertrophy of the rest. Those small yellow grains varying in size from a millet-seed to a pea or to a hazel-nut, are not distinct lobules in a variable state of hypertrophy, but small uncongested patches composed of parts of several adjoining lobules, and having a single or several interlobular spaces for a centre. Hence it is, as we have before shown, that Cruveilhier § has observed the "partie centrale de chaque granulation repond au radicule biliare, et consequemment est souvent teinte en jaune et que la partie excentrique repond à l'element vasculaire et consequemment est plus rouge que la partie centrale."

d. Softening of the liver may accompany any of the changes resulting from acute inflammation. The degree of softening is very variable, the organ having at one time a simple abnormal degree of friability when pressed by the hand, and at others constituting a pulpy mass scarcely retained in its form by the cellular framework of its vessels and Glisson's capsule. Softening may be unaccompanied by any marked change in the bulk of the organ, but is always associated with a variable intensity of venous congestion. Biliary

* Mémoire de la Societé Médicale d'Emulation.
† Anatomie Pathologique, vol. ii. p. 585.
‡ Anatomie Descriptive, vol. ii. p. 568.
§ Anatomie Pathologique, livraison 12.

congestion is also frequently present, and tinges the substance of the organ with a variable hue of yellow, green, &c. Portal observes that the liver of patients who have died of scurvy is often so much softened that it appears in a state of decomposition, has a reddish brown colour, and resembles the lees of red wine. Baillie remarks that softening of the liver is not uncommon in old persons, that it approaches in consistence to the texture of the spleen, and is of a brownish red colour.

e. Induration of the liver is occasionally attendant upon hypertrophy or atrophy of the organ, but it may also exist with a normal size of the liver without other apparent change than the brownish red tint which it receives from venous congestion, or the various shades of yellow, green, or brown induced by biliary congestion. The density and hardness acquired by the liver in a state of atrophy are sometimes truly astonishing. In a case detailed by Morgagni the organ resisted the knife, and several such instances are to be met with among the writings of the older pathologists.

f. Fatty degeneration of the liver.—Upon referring to the section upon the chemical analysis of the liver, it will be observed that a certain proportion of oily matter is one of its natural constituents. Under the influence of diseased action this quantity is greatly augmented, and increases to such an extent as completely to take the place of the normal structures. Vauquelin has published an analysis of a fatty liver, from which the quantity of oily matter present may be fairly estimated thus; in 100 parts he found,

Oil	45
Parenchyma	19
Water	36
	100

The fatty matter is usually distributed equally through the organ, being apparently infiltrated into the cellular texture of the parenchyma. At other times it is deposited in a mass or forms several collections in different parts of the liver. The fatty liver is greasy upon the surface, and when cut into has the appearance of a section of yellow soap. The vessels seem pressed upon and are scarcely perceptible, while the greasy deposition is divided into angular masses by a coarse and compressed cellular tissue.

Fatty liver is generally consistent and solid in its texture, but sometimes the fat exists almost in a fluid state. Portal has observed the liver quite white and softened almost to the fluidity of melted fat, where no hepatic symptoms existed during life; and he particularly records the case of a woman suffering under a severe form of syphilis in which this condition of the liver existed.

From the name which has been given to this disease by pathologists, *fatty degeneration*, we might be led to infer that the texture of the organ was actually converted into this oily substance. This, however, is quite inconsistent with our knowledge of pathological phenomena. The fatty deposition is obviously an undue secretion of a normal constituent, but whether resulting from irritation from whatever cause, or from absence of vital energy, is a question upon which I am unwilling, without further investigation, to hazard an opinion. With regard to the causes of fatty liver Andral observes, "Les causes sous l'influence des quelles le foie devient le siége d'une sécrétion de matière grasse sont encore inconnues. On n'a émis qu'une hypothèse lorsq'on a dit que la dégénération graisseuse du foie était le produit d'une irritation de cet organe. Car on pourrait tout aussi bien soutenir que cette dégénération graisseuse, loin d'avoir été précédée par un état d'irritation du foie, est survenue parceque la nutrition de cet organe est devenue moins active; et cette dernière hypothèse serait d'autant plus soutenable, qu'elle se déduirait d'une grande loi de l'économie en vertu de laquelle, toutes les fois qu'un organe tend à s'atrophier, une matière grasse vient à se sécréter autour de cet organe ou à la place même de ses molécules."*

Fatty liver is most frequently observed in persons who have died from scrofulous tubercles in the lungs; in those, says Andral, in whom the blood has not been efficiently arterialised, and in whom the pulmonary exhalation is greatly diminished. Can it be, he inquires, from the absence of the due separation of hydrogen from the lungs that this compound of hydrogen, fat, becomes deposited in the parenchyma of the liver? This question is well deserving the attention of pathologists, and its solution might lead to important information. The disease has also been observed in some cancerous disorders and in dartrous diseases of of the skin.

g. Pus. Abscess in the liver occurs in two principal forms, either as a single abscess of large size inclosed in a cyst, or as numerous small collections of matter, bounded by the substance of the liver or diffused amongst its lobules. In the first form it constitutes idiopathic abscess of the liver, a disease of tropical countries, and rare in our temperate climates. Abscess is generally preceded by acute inflammation and more rarely by chronic inflammation, and attains an enormous size, engrossing the whole of the right lobe and sometimes converting the entire organ into one huge cyst. The cyst may be thin or thick, and more or less organised. Andral and Louis conceive that its internal surface is analogous to a mucous membrane. The quantity of pus contained in one of these abscesses varies from a few ounces to several pints. My friend Dr. Macnaught, who has seen much practice in the West Indies during a residence of twenty-two years in Jamaica, has observed that abscess in the liver occurs more rarely in the West than in the East, and, moreover, that this disease affects the Europeans and not the Negroes. During the whole of his experience he never saw a single case of abscess in the liver in the Negro, and among the white population of his district only four well-marked instances.

* Anatomie Pathologique, vol. ii. p. 597.

The irritation of abscess causes the effusion of lymph and adhesion to the abdominal parietes or to the adjoining viscera; ulceration follows, and the contents of the cyst are discharged through the artificial opening. The situations in which the matter escapes from the cavity of the abscess are various. 1. It may burst externally, making its way either between the ribs or upwards towards the axilla. In a case observed by Dr. Macnaught the abscess pointed at the epigastrium and was opened by the surgeon in attendance. 2. It may become adherent to the diaphragm and burst into the pleura. 3. It may cause adhesion between the serous membrane of the liver and of the diaphragm, and between the latter and the pleura pulmonalis, and the matter may escape into the lung and be coughed up, as in the case already detailed, which occurred to Dr. Munro. 4. In rare cases the pus has been effused into the cavity of the peritoneum. 5. The abscess may become adherent to the stomach, duodenum, or colon, and the matter be discharged into the alimentary canal. A well-marked case of abscess discharging its contents into the stomach occurred to myself in the case of a woman who has since perfectly recovered. About two pints of matter were vomited by the patient. In a similar case observed by Dr. Macnaught the patient recovered. In two other cases, where the matter was poured into the intestines, the patients died. 6. Abscess has been seen to open into the gall-bladder, and the pus to be conveyed thence through the ductus communis choledochus into the duodenum. 7. In one case the matter was discharged into the vena cava; and in another, 8, described by Dr. Smith, into the pericardium; and in a case detailed by Dr. Graves,* the abscess opened both into the stomach and pericardium.

Besides the preceding form of abscess, which is idiopathic in its origin, abscess may occur in the liver from external injury, as from a blow. The inflammation attending upon this injury is much slighter than that which gives rise to idiopathic abscess; the collection of matter is generally smaller, and terminates either by discharging its contents or by absorption.

The second variety of abscess in the liver, that in which numerous purulent collections exist, depends for its cause upon the occurrence of wounds or of surgical operations. The succession of abscesses in the liver from wounds, particularly of the head, has long since been admitted as a well-established fact, for the explanation of which numerous theories have been invented. Theory, however, has now yielded before facts,—facts, too, of the most interesting and satisfactory kind, for which pathology is indebted to the genius and industry of Cruveilhier. The experimental researches † of this excellent author, published in 1826, enabled him to establish a law of the utmost importance in the consideration of the phenomena of disease, viz. that "tout corps etranger introduit en nature dans le systeme veineux determine lorsque son elimination par les emonctoires est impossible des abscès viscéraux entièrement semblables à ceux qui succèdent aux plaies et aux opérations chirurgicales, et ces abscès sont le resultat d'une phlebite capillaire de ces mêmes visceres."* These experiments consisted in the introduction of metallic mercury into the veins of an animal, say of the lower extremity. In the course of twelve, eighteen, or twenty-four hours the animal experienced much difficulty of breathing, and soon expired. Upon inspection globules of the mercury were found in the lungs. If a smaller quantity of mercury were introduced the animal would live for several days or weeks, and upon examining the lungs at different periods the globules were at first seen to be surrounded by a red induration and afterwards by pus. This experiment was varied by pouring the mercury into the medullary cavity of a bone with precisely the same results; in one instance he placed a single globule in the medullary cavity and found it again at the end of a month in the lungs, divided into several minute globules, each of which formed the centre of a small tuberculous abscess. Cruveilhier then injected a small quantity of mercury into one of the omental veins of a dog—the subject of umbilical hernia; the dog was killed in the third month after the operation, being reduced to a state of marasmus. Upon inspection the liver was found filled with small abscesses, each surrounding a small globule of mercury. Having by means of these experiments satisfied himself that the lungs were the barrier to all foreign matters introduced into the general circulation, as was the liver of those admitted into the abdominal circulation, he proceeded to another series of experiments. Opening a vein in the hinder extremity of a dog he introduced into it a long piece of stick, which gave rise to phlebitis and the secretion of pus. The pus thus produced being carried into the circulation excited, in the first instance, abscesses in the lungs, and, secondly, in the liver. Upon these facts and upon a multitude of excellent observations Cruveilhier founds his opinion that abscess in the liver from wounds and surgical operations is always preceded or accompanied by purulent collections in the lungs, and always results from the same cause, viz. from capillary phlebitis, consecutive upon phlebitis in the neighbourhood of the wound, and immediately produced by the irritative action of globules of pus brought from the diseased veins to the capillaries of the structures in which the secondary suppuration is developed.

In every case of secondary abscess in the liver, following wounds of the head, or after amputation or operations upon bones, Cruveilhier has found phlebitis of the vessels situated in the structure of the bones. Hence he establishes an important general proposition, that "le phlébite des os est une des causes les plus fréquentes des abscès viscéraux suite des plaies et des opérations chirurgicales dans

* Dublin Medical Journal, January 1839.

† Recherches sur la siege immed. de l'inflammation. Nouv. Bibl. Med. vol. iv.

* Anatomie Pathologique, liv. xi.

lesquelles ces os ont été intéressés." The removal of hæmorrhoids and operations upon the uterus are sometimes followed by abscess of the liver, a circumstance which is easily explicable upon the principles so clearly demonstrated by this author.

An excellent instance of secondary abscess of larger size than usual has been kindly furnished to me by my friend and colleague Mr. Rutherford Alcock, who, from his official position in Spain and Portugal during the recent struggles, has had much experience in injuries to the head. A man received a bayonet wound in the scalp, and died upon the fourteenth day after his admission into the hospital. Upon inspection there was observed thickening of the dura mater and a small quantity of matter upon the pia mater. No pus was discovered in the lungs, but a large abscess was found occupying the greater part of the right lobe. A statistical report from a work upon gun-shot wounds by the same author is also interesting. "Of scalp wounds, with and without abrasion, there were sixty-one; two only died, and one only presented disease of the liver; the other died from an attack of erysipelas."

The pathological changes which take place in the liver in these cases are, in the first instance, effusion of blood and lymph and induration around the inflamed vein; secondly, a secretion of a yellow concrete pus into the minute veins and among the lobules, giving to the liver, as Cruveilhier remarks, a granite-like appearance. In the next place the pus collects into small abscesses lodged in irregular cells, which increase in size by continued secretion and by communication with other cells. All these collections of matter are surrounded by a congested circle, which gives them a peculiar and characteristic appearance. After having existed for some time Cruveilhier has observed that the pus becomes converted into a concrete mass, very closely resembling the matter of scrofulous tubercle.

h. Tubercle in the liver is a disease of rare occurrence, and has seldom been observed independently of the existence of similar depositions in the lungs and other organs of the body, and of general indications of a scrofulous diathesis. When present, it exists in the form of small rounded tubercles, generally numerous, and varying in size from that of a millet-seed to a hazel-nut. They are composed of the soft cheesy or curdy deposit which is characteristic of this disease, and have a tendency to a brownish colour. The tuberculous matter is deposited in the tissue of the lobules by infiltration, and the lobules immediately surrounding the tumours are compressed and congested. The obstruction to the circulation in the organ being general on account of the number of the tubercles, the entire liver is more or less congested.

i. Scirrhus.—Carcinoma affects the liver under a variety of forms, but appears most frequently as tubercles of different size and consistence. These tubercles are more frequent than those of scrofulous origin, and are generally accompanied by symptoms denoting a cancerous diathesis, and by the existence at the same time of similar tumours in other parts of the body. In their earliest development in the liver nearly all carcinomatous tumours present the same characters, resembling small, whitish, semi-opaque patches, occupying the tissue of one or of several of the lobules. As they increase in size they put on certain peculiar appearances, which have gained for them a subdivision into species and varieties. I do not intend in this place to enter into the arrangements proposed by authors, but will briefly describe the most striking varieties that have fallen beneath my own examination. The simplest of these tumours has been termed *scirrhous tubercle*, a name which appears particularly applicable from its resemblance in characters and structure to the same form of tumour occurring in other parts of the body. Commencing like the carcinomatous tumour generally in a semi-opaque patch, the outline of the lobules is for some time distinctly perceptible through its area, but at a later period the centre of the patch becomes quite opaque, and presents a cartilaginous hardness nd creaking sound when divided with the knife. The circumference is gradually diffused in the surrounding textures, and the progressive increase of the tumour seems to take place by the secretion of a milky albuminous fluid into the meshes of the lobular venous plexuses. The circulation in these plexuses is at first unimpeded, but by the increase and induration of the secretion it is gradually arrested, and the vessels obliterated. The obliterated vessels give rise to the appearance of small cells, in which the carcinomatous matter is deposited, and the larger areæ are produced by the tissue of the capsules of the lobules variously distorted from their original form by the increased deposition. As the tumours become more and more large, white lines, formed by compressed cellular tissue, are observed radiating from the centre towards the circumference. When seen upon the surface of the liver, the scirrhous tubercle appears flat, or very slightly depressed towards the centre. In a preparation of this form of tubercle now before me, the whole tumour is slightly raised above the surface; it presents no central depression, is cartilaginous in appearance, and has an irregular outline. Its section is dense and hard like cartilage, with no appearance of vessels, and of that pearly and semitransparent whiteness which is generally observed in scirrhous tubercle, particularly in the variety which this preparation illustrates. Sometimes these tubera are small and very numerous, of a yellowish or brownish colour, and have a great activity of increase; the cells in which they are contained are thick and of larger size, and the albuminous secretion less firm than in the preceding variety. Occasionally they are reddened in the centre by the effusion of blood, from the congestion of unobliterated vessels, and sometimes by the continuation, through the tumours, of dilated vessels, which supply them with nutrition. In their enlarged state they frequently coalesce and give rise to an irregular

compound mass, which assumes the form of the particular part of the organ in which it is placed, and is divided into compartments, marking its original multiple form by septa of condensed Glisson's capsule supporting dilated vessels. It would appear to be this form of tumour which has been described by Farre as the first variety of his tubera diffusa; he gives them the following character. "Tubera, elevated at the surface of the organ, but not uniform in their figure, some rising with a regular swell into a round form, others acquiring a margin by being gradually depressed towards the centre, forming tumours without cysts, almost pulpy in their consistence, cellular in their structure, and containing an opaque white fluid."

Another form of the albuminous carcinomatous tumour is the "large white tubercle" of Baillie, the tubera circumscripta of Farre, by whom they are thus admirably described: "Their colour inclines to a yellowish white, and their projecting surfaces, slightly variegated with red vessels, deviate from a regular swell by a peculiar indentation at or near their centres, which are perfectly white and opaque. They vary much in size, which depends on the duration of each tuber, for at its first appearance it is very minute, but during its growth it assumes the character above described, and at its maturity exceeds an inch in its diameter. They adhere intimately to the liver, and their figure is well defined. They commonly remain distinct at the surface of the liver, but internally they ultimately coalesce and form immense morbid masses which pervade its substance. They possess so close a cellular structure that the section of them at first view appears solid and inorganic; but on the edge of the knife, by which they have been dissevered, an opaque white fluid of the consistence of cream is left, and a fresh portion of this fluid is gathered on it at each time that it is repassed over the surface of the section. Their cellular structure becomes more apparent after long maceration."

The depression in the centre of carcinomatous tumours, although generally met with, is not a necessary character of cancer. Its mode of formation has been ably pointed out by Dr. Carswell, in his beautiful work on pathological anatomy: "The depression is not observed unless when the tumour is divided or is situated on the surface of an organ, as the liver, where tumours of this kind are generally met with. In the former case the depression arises from the softer substance, after the division of the tumour raising itself by its elasticity above the unyielding nucleus; in the latter it is produced by the peritoneum adhering to the surface of the tumour when small, and preventing its development in that direction. If the tumour does not come in contact with the peritoneum until it has acquired a considerable size, it presents no such depression, or only a very small one. Hence the reason why, in carcinoma of the liver, we meet with some tumours having a smooth globular surface, and others with a central depression of greater or less extent."

Another variety of carcinomatous tumour is named the gelatiniform cancer, from the existence of a firm and jelly-like deposit which occupies the cells of the tumour in place of the albuminous secretion common to the preceding forms. I have before me an interesting specimen of gelatiniform tubercle. The liver contains a considerable number of these tumours of variable size, and dispersed through every part of its structure. The smallest resemble the small patches described above as the incipient stage of carcinomatous tumour generally; the largest are equal in size to a walnut. They are distinctly circumscribed, and the lobules immediately surrounding them are flattened and compressed. In the smaller tubercles the form of the lobules is quite distinct, but in the larger the lobules have yielded to the peculiar characters of the disease. On the surface the centre of the tubercle presents an oval or circularly indented ring, around which the tumour swells suddenly and then subsides to the circumference. On making a section of one of these tumours, I found a central area of about two lines in diameter, transparent, dense, and apparently gelatinous, and distinctly bounded by a white marginal line; the marginal portion of the section forming the bulk of the tumour was elastic, and rose above the central area to subside gradually in the marginal line of the circumference. The whole section bore a striking resemblance to the conjunctiva affected with chemosis, only that it was paler in its colour, or to a beautiful flower with a single large and expanded circle of petals. On examining a thin section with a lens of low power a number of minute parallel injected capillaries were seen traversing the marginal portion of the tubercle towards the boundary line of the area, but no vessels could be traced beyond that line into the central portion. The resemblance to the petals of a flower was produced by white lines which radiated from the boundary line of the area to the circumference, and divided the marginal portion of the tumour into six or eight compartments. From careful examination it appeared to me that the central area was a single lobule expanded by the gelatinous deposition with which its tissue was infiltrated, and the marginal compartments presented a similar character.

k. Medullary sarcoma.—Another form of tubercle, associated with the cancerous diathesis and belonging to the carcinomatous family, is medullary sarcoma, or encephalosis. The tumours produced by this disease are larger than scrofulous tubercles, and more regular in form and fewer in number than scirrhous tumours. Developed originally in the same way with scirrhus, by infiltration into the tissue of the lobules, or into the vessels themselves, of the peculiar greyish white and opaque substance of which they are composed, they increase in size and obstruct the circulation in the surrounding lobules. Their internal structure is a loose cellular base, filled with a soft and brain-like matter, frequently coloured with blood, or containing coagula in various stages of softening, resulting from hæmorrhagic extravasation.

Sometimes these tumours present a certain degree of consistence, but as they increase in size they become more and more softened and pulpy. Baillie describes a large tumour in the liver which he considers scrofulous from being softened in the centre, and containing a fluid resembling pus; this is most probably a tumour of the kind I am now describing. Another tumour, of which he expresses himself at a loss to understand the nature, soft, of a brownish colour, and of about the size of a nut, appears to be also referable to the same species.

The second and third varieties of the tubera diffusa of Farre present characters resembling this disease. V. 2. "Tubera, elevated at the surfaces of the affected organ, encysted, or having distinct cells, formed by the growth of a fungus, which separates in flakes, and is composed of a fine reticular texture, containing an opaque white fluid." V. 3. "Tumours rising with a regular swell from the surfaces of the affected parts and yielding to the touch, composed of a very delicate reticular texture, pulpy in its consistence, varying in its colour even in the same subject, charged with an opaque fluid, and growing from cysts or cells."

Cruveilhier considers the venous capillary system as the seat of origin of carcinoma, particularly of the form which I am now considering; hence he observes, "Ayant exprimé d'une coupe faite à un foie cancéreux une matière d'un blanc-rougeâtre, encéphaloïde qui se moulait à la manière du vermicelle, et qui pouvait acquérir en se tordant une grande longueur, j'aperçus sur cette coupe un orifice plus considérable que les autres ; j'incisai cet orifice et je parvins dans un vaisseau très volumineux qui me parut être une des ramifications de la veine porte. Alors je disséquai avec beaucoup d'attention cette veine, et je ne fus pas peu étonné de voir que cette veine, depuis les plus grandes jusq'aux plus petites divisicns, était remplie par cette matiere encéphaloïde, adhérente aux parois et tout-à-fait semblable à celle qu'on exprimait par les coupes faites au foie. Il me fut facile de suivre les ramifications extrêmement dilatées de la veine jusque dans l'areoles des coupes. L'altération était bornée à la veine porte, les veines hépatiques et leurs ramifications étaient parfaitement saines."*

l. Fungus hæmatodes is the term applied to all carcinomatous tumours which have a tendency to the unnatural development of new vessels and to effusions of blood into their tissue. In the same organ, hard and cartilaginous scirrhous tumours may exist with those of a softer texture, and of a medullary form, and both of these may be mingled together in the soft, elastic, and bleeding mass which constitutes fungus hæmatodes. The tumours of fungus hæmatodes are often of very large size, and by their frequent hemorrhagies give rise to extreme symptoms and the speedy death of the patient. Farre arranges this form of carcinoma among his tubera diffusa, of which it forms the fourth variety, which he thus defines: "Tumours elevated at the surfaces of the liver and inclining to a round figure; pulpy in their consistence, being charged with a thick and opaque fluid, variegated in their colour, chiefly white mingled with red, the former prevailing in their incipient, the latter in their advanced stages, composed of a very vascular and reticular texture, attached either to distinct pouches or to the substance of the liver, and so unlimited and rapid in its growth as to burst or destroy the peritoneal tunic of this organ and to protrude in the form of a bleeding fungus."

m. Melanosis.—Melanosis exists in the liver, as in other structures of the body, 1st, as a melanic secretion infiltrating the cellular structure of the organ, and giving a diffused general blackness to the substance of the lobules; 2d, as a morbid tissue composed of an areolar cellular network, in which the black carbonaceous matter is deposited; or 3dly, as a melanic pigment accompanying carcinoma or tubercle, and imbuing the abnormal tissue with its peculiar colour. The colour of melanosis in the liver varies from a deep chocolate-brown to a rich black. Sometimes it is diffused in patches through the substance of the organ, at other times it exists in the form of rounded circumscribed tubercles of variable size and number. Laennec considers melanosis as an accidental tissue without analogue among the animal tissues; he classes it with cancerous degenerations, and describes it as existing in his two favourite conditions of crudity and softening. But the researches of Cruveilhier have shewn that in many instances melanosis is to be received as a mere pigment, resembling the pigmentum nigrum of the choroid, which impresses its peculiar colour upon natural and morbid tissues, and he has also proved, in opposition to the view entertained by Laennec, that the softened state or state of infiltration very frequently precedes the more dense and encysted form. Melanosis rarely exists in the liver without being at the same time found in various other structures of the body, as in the brain, eye, lungs, heart, spleen, kidney, mucous membrane, muscles, skin, &c.

6. Disorders of function.—The principal function of the liver being the secretion of bile, we shall have to consider under this head the changes which may occur in the secrction of this fluid and in the fluid itself, in consequence of derangement of function in the organ. These disorders may be divided into three kinds:—

a. Suppression of the bile.

b. Alterations in the physical properties of the bile.

c. Alterations in the chemical qualities of the bile.

a. Suppression of secretion of the bile, like suppression of urine, occasionally occurs in the liver. This disease appears to have been known to Darwin,* who calls it "paralysis of the secretory vessels" of the liver; the patients, he says, "lose their appetite, then their flesh and strength diminish in consequencc, there appears no bile in their stools nor in their urine,

* Anatomie Pathologique, liv. 12.

* Zoonomia, vol. ii. p. 5.

nor is any hardness or swelling perceptible in the region of the liver." Kiernan, who has observed several cases of this disease, informs me that the symptoms are sudden jaundice, depression of the powers of the system, and speedy dissolution; upon dissection he found complete absence of bile in the biliary ducts, the mucous membrane of which appeared bleached.

b. Alterations in the physical properties of the bile.—The changes to which the bile is liable are in no wise referable to any particular alteration in the liver. In cases where this organ has been considerably diseased, the secretion of the bile has been found natural and healthy; and in other cases, where a slight degree of congestion was all the apparent pathological derangement, the secretion has assumed a morbid appearance, or has been deficient or superabundant in quantity. Gall-stones are sometimes found in the gall-bladder without any admonitory symptoms during life, and icterus may be a frequent and even a fatal malady without any obstruction appearing in the course of the biliary tubes after death, or without any satisfactory indications of diseased action in the liver. "I have been sometimes astonished," says Andral, "on seeing the enormous quantity of bile which distended the alimentary canal in cases where the slightest degree of congestion existed in its coats, and when the liver appeared in no wise altered." Nay, it has been proved both by observation and experiment that the bile is materially changed in appearance, quantity, and consistence by the mere alteration of diet. Experiments made upon living animals have long since shewn that bile taken from different individuals is capable of producing very different effects upon the animals into whose bodies it has been introduced; thus some will give rise to a trifling irritation, while others will occasion more or less serious symptoms and even rapid death. Some bile may be touched and even tasted without inconvenience, while other bile, precisely similar in appearance, will produce pustular eruptions and ulcerations upon the tongue and upon the lips. "Here then," says Andral, "are serious changes in the bile which are wholly imperceptible to the investigation of anatomy."

The colour of the bile differs very considerably, being sometimes hardly distinguishable from serum, and at other times presenting a variable tint of amber, orange, green, brown, olive, and even black. In consistence it is equally various, being one while limpid and diffluent, and another while black, viscous, and grumous.

c. Alterations in the chemical properties of the bile.—In chemical composition, the alterations in the bile are not less numerous than in its physical properties. In fatty liver the bile has been found composed almost wholly of albumen and water. Under other circumstances the natural constituents are greatly altered in their relative proportion.

The formation of biliary calculi may be referred to disproportionate secretion of the natural elements of the bile, the increased quantity of certain of its constituents giving rise to the deposition and accretion of these substances in a form corresponding with the cavities in which they are produced. Gall-stones have been found in the smaller biliary ducts in the substance of the liver, in the excretory ducts both within and external to the organ, and in the gall-bladder. They have also been met with inclosed in a cyst, formed most probably by the obliteration of one of the hepatic ducts, and adherent to the organ or suspended from it by a pedicle. Malpighi found gall-stones in the small biliary ducts and considered them as petrified lobules. The *size* of biliary concretions is very various, being sometimes exceedingly small, and at other times of considerable bulk. When small they are generally numerous; I have counted upwards of a hundred, and instances are recorded where more than a thousand were found in the gall-bladder. When they are large they are few in number, and frequently single. I have seen the gall-bladder filled with three, two, and even one large calculus. A large oval gall-stone now before me equal in size to a pigeon's egg I removed from the ductus choledochus. Their *form* is equally various with their size and other physical characters. I have now before me gall-stones with a flattened shape, triangular, and tuberculated on the angles and on the surface; others have three equal facettes with sharp or flattened or rounded angles; others again are irregular in their outline and would seem to be moulded to the canals and cavities from which they have been withdrawn. Being stained by the colouring matter of the bile, their *colour* varies with the predominant tint of the secretion in which they have been formed, hence some are reddish brown or black; others are yellow, and others again white; some are mottled yellow and black, or white and black with various shades of green.

In chemical composition there are, according to Andral, five principal varieties of biliary concretions; they are, 1. of yellow colouring matter; 2. of resin; 3. of cholesterine; 4. of picromel; 5. of phosphate of lime. The first kind appears very ill founded, for yellow is a prevailing tint among gall-stones, and is the mere pigment by which cholesterine and the other substances are coloured. By far the largest proportion of gall-stones are formed of cholesterine, either pure, when it presents a white semitransparent mass beautifully cystallized in its interior, or variously tinted with brown, yellow, or orange, and radiating from the centre towards the circumference or from a small central nucleus. The smaller calculi also exhibit upon fracture the same radiated appearance. The gall-stones of resin and picromel may be classed together and considered as biliary concretions formed of inspissated bile probably accreted through the agency of cholesterine. The calculi of salts of lime are less frequent; they are found in the gall-bladder or in the ductus communis choledochus. I have observed them to present two varieties, firstly, incrustations of phosphate of lime upon

the surface of calculi of cholesterine; and secondly, laminated calculi composed of concentric layers of phosphate and carbonate of lime variously coloured and having a central nucleus. The latter form is, I believe, rare; I possess but one specimen; it is of large size, and rough and irregular upon the surface.*

7. *Entozoa.*—The Entozoa met with in the human liver are hydatids or acephalocysts; they are inclosed in a fibrous cyst and are contained in a single parent hydatid vesicle. The internal surface of the vesicle is soft and often pulpy, and covered by minute hydatids which are adherent to its sides. Besides these the parent vesicle is usually filled with a great number of smaller vesicles of variable size. The hydatid cyst generally occupies the right lobe of the liver and increases to a prodigious size, producing absorption of the structure of the organ, and forming adhesions with the neighbouring viscera. The existence of acephalocysts may sometimes be detected during life by the presence of a large tumour in the region of the liver, which forms a projection of the abdominal parietes, is soft and yielding to examination by the hand, and unaccompanied with symptoms denoting cancerous disease. Occasionally the cyst is hardened by deposits of cartilaginous or bony plates. Contracting adhesions with surrounding parts, the hydatid cyst has discharged its contents externally through the abdominal parietes; more frequently, however, it opens into the alimentary canal, as into the stomach or colon. Occasionally it bursts into the cavity of the abdomen, and in one case opened into the lungs, and many of the smaller hydatid sacs were ejected by coughing.

Some small cysts have sometimes been observed in the liver containing a calcareous deposit, mingled with membranous substance resembling fragments of hydatid sacs. These cysts are supposed to result from the spontaneous cure of acephalocysts.

Small intestinal worms have now and then been found in the biliary ducts; these are imagined to have gained admission into those tubes from the duodenum through the ductus communis choledochus.

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* [Mr. Taylor has recently described a specimen of gallstone, consisting essentially of *stearate of lime*. Lond. and Edin. Phil. Mag. 1840.—Ed.]

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